Scilab Textbook Companion for Worked Examples In Engineering In Si Units, Volume Iii, Electrical Engineering by M. Bates[1]

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Book Description

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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

circuit analysis

Scilab code Exa 1.1 finding currents using superposition theorem

```
clc
clear

//input
r1=4;//resistance between point A and B in ohms which is in series with 10 volts d.c. supply.
r2=3;//resistance between points C and D in ohms which is in series with a d.c. supply of 8 volts.
r3=5;//resistance betwwen points F and G in ohms
//arms AB.CD,FG are in parallel with each other.
v1=10;//d.c. supply voltage in the arm AB in volts
v2=8;//d.c. supply voltage in the arm CD in volts

//calculations
//using SUPER POSITION THEOREM
//voltage source of 8 volts is neglected and supply is 10 volts d.c
R1=r1+((r2*r3)/(r2+r3));// total resistance in ohms
bIa1=v1/R1;//current in arm AB in amperes
cId1=v1*(r3/(R1*(r2+r3)));//current in arm CD in amperes
```

```
dIc1= -cId1;
fIg1=(v1/R1)-cId1;//current in arm FG in amperes
//voltage source of 10 volts is neglected and supply
     is 8 volts d.c
R2=r2+((r1*r3)/(r1+r3));//total resistance in ohms
dIc2=v2/R2;//current in arm CD in amperes
aIb2=v2*(r3/(R2*(r3+r1)));//current in arm AB in
    amperes
bIa2= -aIb2;
fIg2=(v2/R2)-aIb2;//current in arm FG in amperes
I1=bIa1+bIa2;//current in 10 V source in amperes
I2=dIc1+dIc2;//current in 8V source in amperes
I3=fIg1+fIg2;//current in arm FG in amperes

//output
mprintf('the currents in the circuit are %3.5f A %3
    .5f A %3.5f A',I1,I2,I3)
```

Scilab code Exa 1.2 finding thevinins equivalent circuit

```
clc
clear

//input
v1=10;// d.c. voltage source in volts present in arm
     1 in series with a 2 ohm resistor
v2=15;//d.c. voltage source in volts present in arm
    2 in series with a 3 ohm resistor
r1=2; //resistance in arm 1 in ohms
r2=3;// resistance in arm 2 in ohms
r3=1.8;//resistance between node formed by arm 1 and
     2 and point A
R=3;//load resistance in ohms placed in arm AB
// point A and B are in open condition and arm 1 and
     2 are in parallel
```

```
//calculations
//thevenin equivalent circuit method
i1=(v2-v1)/(r1+r2);// current in the parallel circuit in amperes
e=v2-(i1*r2);// open cicuit e.m.f in volts i.e. thevenin's voltage
r=r3+((r1*r2)/(r1+r3));// resistance to be considered between AandB in ohms i.e. thevenin's resistance
I=e/(r+R);//current through the load resistance in amperes

//output
mprintf(' the thevenin equivalent generator will have a constant e.m.f. of %3.0f V and internal resistance of %3.0f ohm. \n the current in 3 ohm resistor is %3.0f A',e,r,I)
```

Scilab code Exa 1.3 finding current in a branch using thevinins theorem

```
clc
clear

//input
r1=0.2;//resistance in arm 1 in ohms which is in series with 10 volts d.c. supply.
r2=0.2;//resistance in arm 2 in ohms which is in series with a d.c. supply of 12 volts.
r3=0.4;//resistance in arm 3 in ohms whichis in series with 15 volts d.c. supply .
//arms 1,2 and 3 are in parallel with each other and are parallel with the arm AB.
v1=10;//d.c. supply voltage in the arm 1 in volts
v2=12;//d.c. supply voltage in the arm 2 in volts
```

```
v3=15;//d.c. supply voltage in the arm 3 in volts
R1=2.28;// resistance in arm AB in ohms in one case
R2=5.82;// resistance in arm AB in ohms in another

//calculations
//thevenin equivalent circuit method
e=((v3/r3)+(v2/r2)+(v1/r1))/((1/r1)+(1/r2)+(1/r3));// thevenin's voltage in volts
r=1/((1/r1)+(1/r2)+(1/r3));//thevenin's resistance in ohms
I1=e/(r+R1);// current when resistance in AB arm is 2.28 ohms
I2=e/(r+R2);// current when resistance in AB arm is 5.82 ohms

//output
mprintf('the equivalent generator has a constant voltage of %3.1f V and an internal resistance of %3.2f ohms \n the load currents are %3.0f A and %3.0f A',e,r,I1,I2)
```

Scilab code Exa 1.4 finding a current in a branch using thevinins theorem

```
clc
clear

//input
//AB,BC,CD,DA are arms of a wheatstone bridge
r1=4;//resistance in arm AB in ohms
r2=6;//resistance in arm BC in ohms
r3=5;//resistance in arm CD in ohms
r4=3;//resistance in arm DA in ohms
v=4;//d.c. supply given between points A and C in volt
R=10;//resistance of the detector placed between the
```

```
points B and D in ohms

//calculations
aIb=v/(r1+r2);//current in arm AB in amperes
aId=v/(r3+r4);//current in arm DA in amperes
aVb=aIb*r1;//voltage drop along arm AB in volts
aVd=aId*r4;//voltage drop across arm AD in volts
dVb=aVb-aVd;//since D is positive with respect to B
e=dVb;// open circuit voltage in volts
r0=((r1*r2)/(r1+r2))+((r3*r4)/(r3+r4));//equivalent resistance in ohms when the supply neglected
I=e/(r0+R);//current through the 10 ohms resistance in amperes

//output
mprintf('the current through the detector will be %3.5f A in the direction from D to B',I)
```

Scilab code Exa 1.5 finding current in resistor using nortons theorem

```
clc
clear

//input
v1=21;//voltage of first battery in arm 1 in volts
v2=16;//voltage of second battery in arm 2 in volts
r1=3;//internal resistance of first battery in ohms
r2=2;//internal resistance of second battery in ohms
R=6;//resistance going to be introduced in arm AB in ohms
//arms 1,2 and AB are in parallel
//arm AB is a short circuit path

//calculations
//norton's equivalent circuit method
```

```
Isc=(v1/r1)+(v2/r2);//current through short circuit
   path in amperes
aRb=(r1*r2)/(r1+r2);//equivalent resistance in ohms
//now 6ohm resistor is placed in arm AB
aIb=Isc*((aRb)/(aRb+R));//current through 6 ohm
   resistor in amperes

//output
mprintf('the constants for norton equivalent
   generator are %3.1f A and %3.1f ohm \n the
   current through the 6 ohm resistor is %3.1f A',
   Isc,aRb,aIb)
```

Scilab code Exa 1.6 finding current using nortons theorem

```
clc
clear

//input
v1=5;//voltage of battery in arm 1 in volts
v2=10;//voltage of battery in arm 2 in volts
v3=20;//voltage of battery in arm 3 in volts
r1=3;//internal resistance of battery in arm 1 in
   ohms
r2=8;//internal resistance of battery in arm 2 in
   ohms
r3=24;//internal resistance of battery in arm 3 in
   ohms
//arms 1,2,3 and AB are in parallel with each other
   and AB are in open condition
r4=6;//resistance between node formed by arms 1,2
   and 3 and point A in ohms
R0=7;//load  resistance to be connected in arm AB in
    ohms
//calculations
```

```
//norton's equivalent method
//batteries are neglected. so, only internal resistances remain in the arms
R=1/((1/r1)+(1/r2)+(1/r3));//equivalent resistance in ohms
aRb=R+r4;// total resistance when looked into the circuit from arm AB in ohm
//applying superposition principle to determine the short circuit current
//battery in arm 1 alone is considered
R1=r1+(1/((1/r2)+(1/r3)+(1/r4)));//effective resistance in ohms
I1=v1/R1;//current in amperes
pd=I1*r1;//potential drop across the parallel combination in volts
aIb1=pd/r4;//current in amperes
//battery in the arm 2 alone is considered
R2=r2+(1/((1/r1)+(1/r3)+(1/r4)));// effective resistance in ohms
I2=v2/R2;//current in amperes
V1=I2/((1/r1)+(1/r3)+(1/r4));//voltage in volts
aIb2=V1/r4;//current in amperes
//battery in the arm 3 alone is considered
R3=r3+(1/((1/r1)+(1/r2)+(1/r4)));//effective resistance in ohms
I3=v3/R3;//current in amperes
V2=I3/((1/r1)+(1/r2)+(1/r4));//voltage in volts
aIb3=V2/r4;//current in amperes
Isc=aIb1+aIb2+aIb3;//short circuit current in amperes
I=Isc*(aRb/(aRb+R0));//current through load resistor in amperes

//output
mprintf('Nortons equivalent generator will produce a constant current of %3.3f A and has a shunt resistance of %3.0f ohms \n the current through the external resistor will be %3.1f A',Isc,r2,I)
```

Scilab code Exa 1.7 finding current using nortons theorem

```
clc
clear

//input
//AB,BC,CD,DA are arms of a wheatstone bridge
r1=4;//resistance in arm AB in ohms
r2=6;//resistance in arm BC in ohms
r3=5;//resistance in arm CD in ohms
r4=3;//resistance in arm DA in ohms
v=4;//d.c. supply given between points A and C in
    volt
R0=10;//resistance of the detector placed between
    the points B and D in ohms
//a detector is placed between the point B and D

//calculations
// noerton's equivalent circuit method
R1=((r1*r2)/(r1+r2))+((r3*r4)/(r3+r4));// equivalent
     resistance assuming short circuit between poin A
     and C in ohms
R2=((r1*r4)/(r1+r4))+((r2*r3)/(r2+r3));//equivalent
    resistance assuming short circuit between points
    B and D in ohms
I1=v/R2;// total current in amperes
aIb=v*(r4/(R2*(r4+r1)));//current in arm AB in
    amperes
aVDb=v*aIb;//voltage drop in arm AB
bVDc=v-aVDb;//voltage drop in arm DC
bIc=bVDc/r2;//currrent in arm BC in amperes
dIb=bIc-aIb;//current in arm DB in amperes
Isc=dIb;//short circuit current in amperes
I=Isc*(R1/(R1+R0));//current through the detector in
```

```
amperes

//output
mprintf('nortons  equivalent generator produces %3.5f A and has a shunt resistance of %3.3f ohms \n the current through the detector will be %3.3f A',Isc,R1,I)
```

Scilab code Exa 1.8 delta to star conversion

```
clc
clear

//input
//arma AB,BC and CA forms delta connection
r1=2;//resistance in arm AB in ohms
r2=3;//resistance in arm BC in ohms
r3=5;//resistance in arm CA in ohms

//calculations
//conversion of given delta into star connection
//let N be the star point
R1=(r1*r2)/(r1+r2+r3);//resistance in arm AN in ohms
R2=(r2*r3)/(r1+r2+r3);//resistance in arm BN in ohms
R3=(r1*r3)/(r1+r2+r3);//resistance in arm CN in ohms

//output
mprintf('the respective star connected resistances are %3.1f ohm,%3.1f ohm and %3.1f ohm',R1,R2,R3 )
```

Scilab code Exa 1.9 finding the currents in wheatstone bridge using delta to star conversion

```
clc
clear

//input
//AB,BC,CD,DA are arms of a wheatstone bridge
r1=5;//resistance in arm AB in ohms
r2=20;//resistance in arm BC in ohms
r3=15;//resistance in arm CD in ohms
r4=4;//resistance in arm DA in ohms
v=4;//d.c. supply given between points A and C in volt
r0=0.5;// internal resistances pf the d.c. supply in ohms
r5=15;//resistance in arm BD in ohms

//calculations
//BCD is replaced by equivalent star connection
//assume N as star piont after conversion
bRn=(r2*r3)/(r3+r2+r5);//resistance in arm BN in ohms
cRn=(r2*r5)/(r3+r2+r5);//resistance in arm CN in ohms
dRn=(r5*r3)/(r3+r2+r5);//resistance in arm DN in ohms
R=r0+cRn+(((r1+bRn)*(r4+dRn))/(r1+bRn+r4+dRn));//total resistance in ohms after conversion
I=v/R;//totalcurrent supply in amperes
I1=(v/R)*((r4+dRn)/(r1+bRn+r4+dRn));//current between points A and B in amperes
I2=I-I1;//current between points A and D in amperes
V1=I1*r1;//voltage drop across r1 in volts
V2=I2*r4;//voltage drop across r4 in volts
V3=V2-V1;//voltage drop across r5 in volts and B is positive to D
I3=V3/r5;//current between points B and D in amperes
I4=I1-I3;//current between points B and C in amperes
I5=I2+I3;//current between points D and C in amperes

```

```
//output
mprintf('the currents in each part of the circuit
    are \n It= %3.3f A \n aIb= %3.3f A \n aId= %3.3f
    A \n bId= %3.3f A \n bIc= %3.3f A \n dIc= %3.3f A
    ',I,I1,I2,I3,I4,I5)
```

Scilab code Exa 1.10 star to delta conversion and finding conductances

```
clc
clear

//input
//AN,BN,CN are connected in star fashion where N is
    the nuetral point
r1=5;//resistance in arm AN in ohms
r2=20;//resistance in arm BN in ohms
r3=10;//resistance in arm CN in ohms

//calculations
//star to delta conversion
Y1=1/r1;//conductance of arm AN in seimens
Y2=1/r2;//conductance of arm BN in seimens
Y3=1/r3;//conductance of arm CN in seimens
R1=1/((Y1*Y2)/(Y1+Y2+Y3));//resistance of arm AB in
    ohms
R2=1/((Y2*Y3)/(Y1+Y2+Y3));//resistance of arm BC in
    ohms
R3=1/((Y1*Y3)/(Y1+Y2+Y3));//resistance of arm CA in
    ohms

//ouput
mprintf('the equivalent resistances values for delta
     circuit are %3.0f ohms, %3.0f ohms and %3.1f
    ohms',R1,R2,R3)
```

Scilab code Exa 1.11 finding current using star to delta transform

```
clc
clear

//input
//AB,BC,CD,DA forms an unbalanced wheatstone's bridge
r1=2;//resistance in arm AB in ohms
r2=5;//resistance in arm BC in ohms
r3=6;//resistance in arm CD in ohms
r4=2;//resistance in arm DA in ohms
r5=10;//resistance of detector placed between the points B and D
v=4;//batterry supplying d.c. voltage in volts which is placed between points A and C
r0=0.2;// internal resistance of the battery in ohms

//calculations
//AB,BC and BD are cosidered to be in star connection with B as star point
Y1=1/r1;//conductacne of r1 in seimens
Y2=1/r2;//conductance of r2 in seimens
Y3=1/r5;//conductance of r5 in seimens
//after delta conversion
R1=1/((Y1*Y2)/(Y1+Y2+Y3));//resistance between points A and B in ohms
R2=1/((Y2*Y3)/(Y1+Y2+Y3));//resistance between points C and D in ohms
R3=1/((Y1*Y3)/(Y1+Y2+Y3));//resistance between points D and A in ohms
Rad=(r4*R3)/(r4+R3);//effective resistance of arm AD in ohms
Rdc=(r3*R2)/(r3+R2);//effective resistance of arm DC
```

```
in ohms
Radc=(Rad+Rdc);//effective resistance if arms AD and DC in ohms
R=r0+((R1*Radc)/(R1+Radc));// total resistance of hte circuit in ohms
I=v/R;//total current in the circuit in amperes
I1=I*(R1/(R1+Radc));//current in arm AD in amperes
I2=I-I1;//current in arm AB in amperes
V1=I1*r4;//voltage across arm AD in volts
V2=I2*r1;//voltage across arm AB in volts
V3=V1-V2;//voltage across arm BD in volts and B is positive to D
I3=V3/r5;//current in arm BD in amperes

//output
mprintf('the current in the detector is %3.3f A',I3)
```

Scilab code Exa 1.12 determining the maximum power transfered

```
clc
clear

//input
// a battery consists of 10cells connected in series
v=1.5;//e.m.f. of each cell in volts
r=0.2;// internal resistance of each cell in ohms
n=10;//number of cells in the battery

//calculations
//for maximum power load resistance=internal resistance
R=n*r;//total internal resistance of hte battery in ohms
Rl=R;//load resistance in ohms
e=n*v;//total e.m.f. of battery in volts
```

```
I=e/(R+Rl);//current from battery in amperes
P=(I^2)*R;//heating loss in the battery in watts
V=e-(I*R);//terminal voltage in volts

//output
mprintf('The maximum value of power which the
    battery may transfer is %3.1f W and an equal
    quantity of power is dissipated in the battery.\
    n under these conditions the terminal p.d. is %3
    .1f V',P,V)
```

Chapter 2

fields

Scilab code Exa 2.1 finding energy stored in magnetic field

```
clc
clear
//input
r=5; //resistance of the coil in ohms
v=100; // d.c supply voltage to the coil in volts
l=100*(10^-3); // inductance of the coil in henry

//calculations
i=v/r; // value of the current in amperes
e=(l*(i^2))/2; // energy stored in the circuit in
    joules

//output
mprintf('the value of current is %3.2f amperes  \n
    the energy stored in the magnetic field is %3.2f
    joules',i,e)
```

Scilab code Exa 2.2 finding energy stored in magnetic field

```
clc
clear

//input
l=0.5; //length of an air cored cylinder in meters
d1=0.05; // diameter of an air cored cylinder in meters
n=400; //number of turns of copper wire wound around the cylinder
d2=0.001; //diameter of the copper wire wound in meters
v=14; //dc supply voltage in volts
r=1.71*(10^-8);// resistivity of copper in ohm meteres
u0=1.257*(10^-6); // permeabilty of free space
ur=1; //relative permeability

//calculations
L=(u0*ur*(n^2)*(%pi*(d1^2)))/(4*l); //inductance of the coil in henry
R=(r*n*(d1+d2)*%pi*4)/(%pi*(d2^2)); // resistance of the field in ohm
i=v/R; //current in the field in amperes
e=(L*(i^2))/2; // energy stored in the field in joules

//output
mprintf('the inductanec of the coil is %3.10f H \n the resistance of the field is %3.10f ohm \n the energy stored in the field is %3.10f J',L,R,e)
```

Scilab code Exa 2.3 finding energy stored

```
clc
clear
```

```

//input
mmf=1800; // magneto motive force in amperes
l1=0.8; // length of iron in meters
l2=0.002; //length of air gap in meters
a=9*(10^-4); // area of the air gap in square meters
ui=2000; // relative permeability of iron
ua=1; // relative permeability of air
u0=1.257*(10^-6); // absolute permeability of free
    space

//calculations
b=(mmf*u0)/((l1/ui)+(l2/ua)); // flux density in
    tesla
e=(b^2)/(2*u0*ui); //energy stored in joules/cubic
    meter
v=l1*a; // volume of the iron in cubic meters
E=v*e; // total energy stored in the iron in joules

// output
mprintf('flux density is %3.10f T \n energy stored
    is %3.10f J/cubic m \n volume of the iron is %3
    .10f cubic m \n total energy stored in the iron
    is %3.10f J',b,e,v,E)
```

Scilab code Exa 2.4 estimation of coupling factor

```
clc
clear

//input
l1=0.4; //inductance of the first coil in henry
    which is in series with the second
l2=0.1; //inductance of the second coil in henry
i=5; // current through both the coils in amperes
```

```
e=2.25; // energy stored in magnetic field in joules

//calculations
L=(2*e)/(i^2); //total inductance in henry
M=(l1+l2-L)/2; // mutual inductance between the
    coils in henry
K=M/((l1*l2)^(0.5)); // coupling factor between the
    coils

//output
mprintf('total inductane is %3.10f H \n mutual
   inductane between the coils is %3.10f H \n the
   coupling factor is %3.10f',L,M,K)
```

Scilab code Exa 2.5 finding the load that can be lifted by a magnet

```
clc
clear

//input
l1=0.5; //length of iron bar in meters which is bent
     into horse shoe lifting magnet
a=1*(10^-3);// cross sectional area in cbuc meters
n=500; // number of turns wound
i=4; //cyrrent flowing in amperes
ui=1100; // relative permeability of iron
ua=1; //relative permeability of air gap
l2=0.001; //length of the air gap
k=1.1; //leakage co-efficient
u0=1.257*(10^-6); //absolute permeability

//calculations
b=(n*i*u0)/(((k*l1)/ui)+((2*a)/ua)); //flux density
   in tesla
P=((b^2)*2*l2)/(2*u0*ua); //increase in stored
```

```
energy due to movement of the load by magnet in joules
m=P/9.81; //mass lifted in kilo grams

//output
mprintf('fulx density is %3.10f T \n increase in stored energy is %3.2f J \n mass that can be lifted by the magnet is %3.2f Kg',b,P,m)
```

Scilab code Exa 2.6 finding area of hysterisis loop and power loss

```
clc
clear

//input
h=500; //hysteresis losses of the rotor of a d.c. machine in joule/cubic meter/cycle
n=50; //number of cycles of magnetisation
d=0.0075; //density of the material in mg/cubic meter
H=10; //magnetising force in ampere/mater per mm when hysteresis loop is plotted on a graph
B=0.02; //flux density in tesla per mm when hysteresis loop is plotted on a graph

//calculations
e=B*H; //energy represented by 1square mm in joules
a=h/e; //area of loop in square mm
p=h*n; //power loss in watts per cubic meter
P=(p*(10^-6))/d; //power loss in watts per Kg

//output
mprintf('the area of hysteresis loop is %3.10f sq.mm \n the power loss is %3.10f W/Kg',a,P)
```

Scilab code Exa 2.7 finding the speed of a machine

```
clc
clear

//input
p=6; //number of poles of a d.c. machine
v=0.01; // volume of iron in cubic meters
d=0.0079; //density of the iron in mg/square meter
hi=4; // hysterisis loss of iron in W/Kg
hl=619; //loss given by hysteresis loop in joule/cubic meter/cycle

//calculations
h=hi*d*v*(10^6);// total hysteresis losses in watts
f=h/(hl*v);// frequency in cycles/second
n=(f*60)/3; //rotor undergoes 3 cycles of magnetisation in each revolution and speed in rev/minute
a=(f*2*%pi)/3; // angular velocity if rotor in radian per second

//output
mprintf('the speed of the machine will be %3.10f rev/min or %3.10f rad/s',n,a)
```

Scilab code Exa 2.8 finding maximum permissible volume of transformer core

```
clc
clear

```

```
//input
a=2500; //area of hysteresis loop in square millimeter
H=16;//magnetising force in ampere/mater per mm when hysteresis loop is plotted on a graph
B=0.02;//flux density in tesla per mm when hysteresis loop is plotted on a graph
hloss=24;//desired hysteresis loss
n=50;//cycles of magnetisation

//calculations
e=B*H;//energy represented by square millimeter
l=a*e;//loss/cubic meter/cycle
Vmax=hloss/(l*n);//maximum volume core in cubic meter

//output
mprintf('the permissible volume of the transformer core is %3.10f cubicmeter',Vmax)
```

Scilab code Exa 2.9 comparing energies stored in different fields

```
clc
clear

//input
l=0.002;//length in meters
a=0.01;//area in square meters
pd=250000;//potential gradient in V/m
h=250000;//magnetic force in A/m
e0=8.85*(10^-12);//absolute permittivity
er=1;//relative permittivity of  air
u0=1.257*(10^-6);//absolute permeability
ur=1;//relative permeability of air

```

```
//calculations
D=e0*er*pd;//electric flux density in C/sq.m
Ee=((D^2)*l*a)/(2*e0*er);//energy stored in electric field in joules
B=h*u0*ur;//magnetic flux density
Em=((B^2)*l*a)/(2*u0*ur);//energy stored in magnetic field
k=Ee/Em;//ratio of energy in electric field to magnetic field

//output
mprintf('the ratio of energies in electric to magnetic field is %3.10f :1',k)
```

Scilab code Exa 2.10 finding energy stored in capacitor

```
clc
clear

//input
c1=2*(10^-6);// capacitance of first capacitor in farad which is connected in series with second
c2=6*(10^-6);// capacitance of second capacitor in farad which is connected in series with first
v=240;//d.c. voltage supply in volts

//calculations
ct=(c1*c2)/(c1+c2);//effective capacitance in farad
q=ct*v;//total charge in coloumbs
e1=(q^2)/(2*c1);// energy stored in first capacitor in joules
e2=(q^2)/(2*c2);// energy stored in second capacitor in joules

//output
```

```
mprintf('the energy stored in first capacitor is %3
    .10f J \n the energy stored in second capacitor
    is %3.10f J',e1,e2)
```

Scilab code Exa 2.11 finding potential difference and different energies

```
clc
clear

//input
c1=0.000005; //capacitance of first capacitor in
    farad
c2=0.000003;//capacitance of second capacitor in
    farad
v=200; //potential difference to which capacitor is
    charged in volts

//calculations
q1=c1*v;// charge given to first capacitor
ct=c1+c2;// total capacitance in farad
pd=q1/ct;// final potential difference across
    combination in volts
Eo=(c1*v*v)/2;//original energy in system in joules
Ef=(pd*pd*(c1+c2))/2;//final energy in system in
    joules

//output
mprintf('the initial energy stored in the capacitor
    is %3.10f J and final energy stored in the
    combination is %3.10f J',Eo,Ef)
```

Scilab code Exa 2.12 finding equivalent resistance

```
clc
clear

//input
c=0.000002;// capacitance of a capacitor in farad
theta=0.12; // loss angle in radians
v=230; // a.c. voltage supply in volts
f=50; //supply frequency in hertz

//calculations
ic=v*2*%pi*f*c;// capacitor current in amperes
ir=ic*tan(theta);// current through shunt resistance
    in amperes
r=v/ir;// shunt resistance in ohm

//output
mprintf('the value of the equivalent shunt
   resistance is %3.10f ohm',r)
```

Scilab code Exa 2.13 finding energy dissipated in a material

```
clc
clear

//input
s=1;//side of square piece of wood which is clamped
   between two mettalic plates in meters
t=0.005;//thickness of square piece of wood which is
    clamped between two mettalic plates in meters
pd=20;//applied potential difference in volts
f=25000000;//supply frequency in hertz
er=4;//relative permittivity of the wood
theta=0.2// loss angle in radians
T=10;//time in minutes
e0=8.85*(10^-12);//absolute permittivity
```

```

//calculations
P=(pd*pd*2*%pi*f*e0*er*s*s*theta)/t;// power loss in
    watts
E=P*60*T;// energy dissipated in ten minutes in
   joules

//output
mprintf('the energy dissipated in the wood in 10 min
    is %3.10f J',E)
```

Chapter 3

d c machines

Scilab code Exa 3.1 determination of angular speed

```
clc
clear

//input
n1=420;//number of conductors in armature of a d.c.
   machine
phi=0.024;//flux produced by each pole in weber
e=250;//desired e.m.f in volts
n2=4;//number of poles of the d.c. machine

//calculations
N=n1/2;//number of conductors per path and there are
    two parallel paths
//e1= e.m.f induced per conductor=(4*0.024*w)/(2*%pi
   ) where w is the required angular velocity in rad
   /s
w=e/((n1*(48*10^-3))/(2*%pi));//required angular
   velocity in rad/s

//output
mprintf('the armature of hte machine must have an
```

```
angular velocity of %3.0f rad/s',w)
```

Scilab code Exa 3.2 finding output of a machine in different cases

```
clc
clear

//input
n1=200;//number of armature conductors
i=5;//current capability of each conductor in amperes
n2=4;//number of poles in the machine
e=1;//e.m.f. induced in each pole in volts

//calculations
//for a wave winding
n3=2;//number of parallel paths
n4=n1/n3;//number of conductors per path
e1=e*n4;//e.m.f of the machine in volts
i1=n3*i;//current capacity in amperes
op1=i1*e1;//output of the machine in watts
//for a lap winding
n5=n2;//number of parallel paths=number of poles
n6=n1/n5;//number of conductors per path
e2=n6*e;//e.m.f. of the machine in volts
i2=n5*i;//current capacity in amperes
op2=i2*e2;//output of the machine in volts

//output
mprintf('the output of the machine if armature is wave wound is %3.3f W and lap wound is %3.3f W',op1,op2)
```

Scilab code Exa 3.3 finding induced emf

```
clc
clear

//input
n1=480;//number of conductors in the armature
n2=6;//number of poles in the machine
w=100;//angular velocity in rad/s
phi=0.03;// flux per pole in weber

//calculations
phi1=n2*phi;//flux cut by each conductor in weber
e1=(phi1*w)/(2*%pi);//e.m.f. induced/conductor in
   volts
n3=n2;//number of parallel paths
n4=n1/n3;//number of conductors per path
e2=e1*n4;//e.m.f. per path in volts

//output
mprintf('the e.m.f. induced in the armature is %3.0f
    V',e2)
```

Scilab code Exa 3.4 determination of torque produced

```
clc
clear

//input
n1=16;//number of coils under the influence of the
   poles at any instant
phi=0.03;//flux produced by each coil in weber
a1=(200*300*(10^-6));//area of a pole in square
   meter
n2=8;//number of turns in each coil
```

```
d=0.25;//diameter of the armature in meters
i=12;// current in the armature conductors in
    amperes
l=0.3;//length of the pole in meters

//calculations
b=phi/a1;//flux density under poles in tesla
f1=b*i*l;//force acting on 1 conductor in newton
f2=n2*f1;//force per coil side in newton
t1=f2*(d/2);//toque per coil side in newton meter
t2=t1*2;//total torque per coil in newton meter
T=n1*t2;//total torque on armature in newton meter

//output
mprintf('the total exerted on the armature is %3.1f
    Nm',T)
```

Scilab code Exa 3.5 finding power output of the motor

```
clc
clear

//input
d=0.25;//diameter of a pulley placed on the end of
    hte shaft of a d.c. motor in meter
m=60;//mass attached by a rope to the pulley in kg
w=50;//angular velocity of the pulley in rad/sec

//calculations
f=m*9.81;//force acting on the pulley in newton
    meter
W=f*%pi*d;//work done in one revolution
v=(d/2)*w;
p=(f*v)/1000;//power in kilo watts

```

```
//output
mprintf('yhe output of the motor is %3.2f kW',p)
```

Scilab code Exa 3.6 finding required torque

```
clc
clear

//input
e=235;//e.m.f generated by an armature of a d.c. machine in volts
v=100;//velocity of armature of a d.c. machine in rad/s
i=16;//current in amperes

//calculations
p=e*i;//power of armature in watts
t=p/v;//required torque in newton meter

//output
mprintf('required torque is %3.1f Nm',t)
```

Scilab code Exa 3.7 finding required flux per pole

```
clc
clear

//input
n1=4;//number of poles in a d.c. machine
n2=290;//number of conductors in the armature which are connected in lap winding
i=20;//armature current in amperes
t=50;//torque produced in newton meter
```

```
//calculations
phi=((t*(2*%pi))/(n2*i))*1000;//required flux per
    pole in milliweber

//output
mprintf('the required flux per pole is %3.1f mWb',
    phi)
```

Scilab code Exa 3.8 finding terminal voltage of a shunt generator

```
clc
clear

//input
ra=0.05;//armature resistance of a d.c. shunt
    generator in ohms
rf=120;//feild resistance of a d.c. shunt generator
    in ohms
li=98;//load current in amperes
lv=240;//load voltage in volts
ia2=60;//reduced current in armature in amperes

//calculations
//generated e.m.f. remains constant
if=lv/rf;//feild current in amperes
ia1=li+if;//armature current in amperes
e=lv+(ia1*ra);//generated e.m.f. in volts
V=e-(ia2*ra);//final terminal voltage in amperes

//output
mprintf('for an armature of 60A the terminal p.d.
    will be %3.0f',V)
```

Scilab code Exa 3.9 finding power developed in the armature

```
clc
clear

//input
ra=0.1;//armature resistance of a shunt generator in
    ohms
rf=250;//feild resistance of a shunt generator in
    ohms
p=7250;//load supplied by the shunt generator in
    watts
v=250;//voltage of shunt generator in volts

//calculations
il=p/v;//load current in amperes
if=v/rf;//feild current in amperes
ia=il+if;//armature current in amperes
e=v+(ia*ra);//generated e.m.f. in volts
P=(e*ia)/1000;//armature power in kW

//output
mprintf('the power developed in the armature will be
    %3.2f kW',P)
```

Scilab code Exa 3.10 finding different efficiencies

```
clc
clear

//input
v=230;//voltage of a shunt generator in volts
```

```
ra=0.2;//armature resistance of the shunt generator in ohms
rf=115;//feild resistance of the shunt generator in ohms
n=0.85;//overall effeciency in per units
il=37;//load current in amperes

//calculations
inp=(v*il)/n;//input in watts
inp1=inp/1000;//input power in kilo watts
fi=v/rf;//feild current in amperes
ai=il+fi;//armature current in amperes
e=v+(ai*ra);//generated e.m.f. in volts
ap=e*ai;//armature power in watts
ml=inp-ap;//mechanical losses in watts
nm=ap/inp;//mechanical effeciency in per units
Nm=nm*100;
ne=(v*il)/ap;//electrical effeciency in per units
Ne=ne*100;

//output
mprintf('the input power will be %3.0f kW and the mechanical losses are %3.0f W \n the mechanical and electrical effeciecies are %3.1f per cent and %3.1f per cent',inp1,ml,Nm,Ne)
```

Scilab code Exa 3.11 finding output of series generator

```
clc
clear

//input
ra=0.08;//armature resistance of a d.c. series generator in ohms
rf=0.1;//feild resistance of a d.c. series generator
```

```
    in ohms
il=50;//load current in amperes
e=250;//e.m.f. generated in volts

//calculations
R=ra+rf;//total resistance of machine in ohms
pd=e-(il*R);//terminal p.d. in volts
p=pd*il;//power output in watts
P=p/1000;//power output in kilo watts

//output
mprintf('the power output of the generator is %3.2f
   kW',P)
```

Scilab code Exa 3.12 finding different efficiencies of a series generator

```
clc
clear

//input
v=240;//voltage of d.c. series generator in volts
ra=0.1;//armature resistancce of d.c. series
    generator in ohms
rf=0.15;//feild resistance of d.c. series generator
    in ohms
n=0.87;//overall effeciency in per units
lp=7200;//load power in watts

//calculations
il=lp/v;//load current in amperes
R=ra+rf;//total resistance in ohms
e=v+(il*R);//generated e.m.f. in volts
ap=e*il;//armature power in watts
ne=(lp/ap);//electrical effeciency in per units
ne1=ne*100;
```

```
nm=(n/ne)*100;//mechanical effeciecy

//output
mprintf('the electrical and mechanical effeciencies
    are %3.0f per cent and %3.1f per cent',ne1,nm)
```

Scilab code Exa 3.13 finding velocity of shunt motor

```
clc
clear

//input
v=250;//voltage of shunt motor in volts
ra=0.2;//armature resistance of shunt motor in ohms
rf=250;//feild resistance of shunt motor in ohms
w=75;//velocity of shunt motor in rad/sec
i1=21;//current taken by the motor in amperes
i2=60;//changed current in amperes

//calculations
fi=v/rf;//feild current in amperes
ai=i1-fi;//armature current in amperes
e1=v-(ai*ra);//induced e.m.f. in volts
e2=v-(i2*ra);//induced e.m.f. for changed current in
     volts
W=w*(e2/e1);//new speed in rad/sec

//ouput
mprintf('with an armature current of 60A the motor
    speed will be %3.1f rad/s ',W)
```

Scilab code Exa 3.14 finding total torque produced

```
clc
clear

//input
v=240;//voltage of a d.c. shunt motor in volts
ra=0.4;//armature resistance of d.c. shunt motor in
    ohms
rf=120;//armature resistance of d.c. shunt motor in
    ohms
is=22;//supply current in amperes
w=600;//angular velocity of motor in rev/min
il=30;//load current in amperes

//calculations
//armature reaction is neglected
W=(w*(2*%pi))/60;//angular velocity in rad/s
fi=v/rf;//feild current in amperes
ai=is-fi;//armature current in amperes
e=v-(ai*ra);//e.m.f. in volts
t1=(e*ai)/W;//torque when current is 20A in newton
    meter
aI=il-fi;//changed armature current in amperes
t2=t1*(aI/is);//torque when current is 30A in newton
     meter

//output
mprintf('with a supply current of 30A the motor
    produces a total torque of %3.1f Nm',t2)
```

Scilab code Exa 3.15 finding overall efficiency of motor

```
clc
clear

//input
```

```
v=250;//voltage of a d.c. shunt motor in volts
ra=0.4;//armature resistance of a d.c. shunt motor
   in ohms
rf=250;//field resistance of a d.c. shunt motor in
   ohms
t=80;//total torque in newton meter
w=75;//velocity in rad/s
ml=0.1;//mechanical losses in per units

//calculations
ap=t*w;//armature power in watts
//(ia^2)-625ia+15000=0 will be the equation obtained
    from the e.m.f. equation
//(-ia+25)(ia-600)=0 is simplified equation
ai=25;//armature current in amperes as 600A armature
    current is inadmissable
fi=v/rf;//field current in amperes
inpI=ai+fi;//input current in amperes
inpP=v*inpI;//power input in watts
outP=0.9*t*w;//output power in watts and 0.9 is used
    after considering the 10% mechanical losses
n=outP/inpP;//overall effeciency in p.u.

//output
mprintf('for the loading condition the overall
   efficiency is %3.3f p.u.',n )
```

Scilab code Exa 3.16 finding speed of armature of dc series motor

```
clc
clear

//input
v=240;//voltage of a d.c. series motor in volts
rm=0.2;//resistance of the motor in ohms
```

```
w=80;// velocity of motor in rad/s
i1=20;//current in amperes
i2=30;//changed current in the armature in amperes

//calculations
//it is assumed that flux/pole is proportional to
   the field current
e1=v-(i1*rm);//e.m.f. induced in volts when the
   current is 20 A
e2=v-(i2*rm);//e.m.f. induced in volts when the
   current is 30 A
W=(e2/e1)*(i1/i2)*w;//final velocity in rad/s

//output
mprintf('with the increased current the motor will
   run with a velocity of %3.2f rad/s',W)
```

Scilab code Exa 3.17 finding required current

```
clc
clear

//input
//for a series motor
i1=40;//current in amperes
t1=110;//torque in newton meter
t2=75;//torque in newton meter

//calculations
//it assumed that up to a current of 50A the
   magnetizing curve for the motor is linear
i2=((t2/t1)*(i1^2))^0.5;//required torque in newton
   meter

//ouput
```

```
mprintf('the current to produce a total torque of 75
   Nm is %3.0f A',i2)
```

Scilab code Exa 3.18 finding total and shaft torque

```
clc
clear

//input
n1=4;//number of poles in a aeries motor
v=240;//voltage of the series motor in volts
n2=348;//number of conductors in the armature which
    is wave connected
r=0.8;//resistance in ohms
i=45;//current taken by the motor in amperes
phi=0.028;//flux/pole in weber
outP=8200;//output power in watts

//calculations
t=(phi*n2*2*i)/(2*%pi);//since wave winding 2 is
    taken and the torque in newton meter
e=v-(i*r);//e.m.f. induced in volts
ap=e*i;//armature power in watts
w=(ap/t);//angular velocity in rad/s
st=outP/w;//shaft torque in newton meter

//output
mprintf('the total torque and the shaft torque
    produced by the motor are %3.0f Nm and %3.0f Nm',
    t,st)
```

Scilab code Exa 3.19 finding speed of the motor

```
clc
clear

//input
v1=240;//voltage of a d.c. shunt motor in volts
ra=1;//armature current in ohms of a d.c. shunt
    motor
rf=240;//field current in ohms of a d.c. shunt motor
ifl=20;//full load current in amperes
w=200;//speed in rad/s
v2=200;//reduced voltage in volts

//calculations
//flux/pole is assumed to be proportional to the
    field current
//for a 240V supply
E1=v1-(ifl*ra);//induced e.m.f. in volts
i=ifl*(v1/v2);//new current in amperes
E2=v2-(i*ra);//induced e.m.f. for new current in
    volts
W=w*(E2/E1)*(i/ifl);//new speed in rad/s

//output
mprintf('with the reduced voltage the motor will run
     at %3.0f rad/s',W)
```

Scilab code Exa 3.20 finding speed of the motor

```
clc
clear

//input
rm=0.5;//resistance of a series motor in ohms
w=100;//velocity in rad/sec
i=25;//current taken by the motor in amperes
```

```
v=250;//supply voltage in volts
r=2.5;//resistance connected in series with armature
    in ohms

//calculations
//armature current remains constant
E1=v-(i*rm);//e.m.f. induced under normal conditions
R=r+rm;//total resistance of circuit in ohms
E2=v-(i*R);//new induced e.m.f. in volts
W=(E2/E1)*w;//new speed for the same current in rad/
    s

//output
mprintf('with resistor in series with the armature
    the motor will run at %3.1f rad/s',W)
```

Scilab code Exa 3.21 finding value of regulator resistance

```
clc
clear

//input
v=240;//voltage of a shunt motor in volts
ra=0.4;//armature resistance in ohms of the shunt
    motor
rf=160;//field resistance in ohms of the shunt motor
ia=30;//armature current in amperes
w=1250;//speed in rev/min

//calculations
//it is assumed that flux is proportoinal to the
    field current
E1=v-(ia*ra);//induced e.m.f. in volts
fi=v/rf;//field current in amperes
k=E1/(fi*w);
```

```
//if=k*(v/r2) where r2 is the resistance to be added
//ia1=(3*r2)/16 and E2=v-(ra*ia1)
//(E2/E1)=((24-0.4ia1)/228) and (E2/E1)=(192/r2)
//we get an equation for r2 as (r2^2)-(3200*r2)
    +583680=0
r21=((3200+(((3200*3200)-(4*1*583680))^0.5))/2);//
    one of two solution for r2 in ohms
r22=((3200-(((3200*3200)-(4*1*583680))^0.5))/2);//
    one of two solution for r2 in ohms
R=r22-rf;//final resistance to be added in ohms and
    r22 is considered as the other value is too large
     and impractical

//ouput
mprintf('resistance to be added is %3.0f ohms',R)
```

Scilab code Exa 3.22 calculation of speed of motor

```
clc
clear

//input
v=250;//voltage of the series motor in volts
ra=0.25;//armature resistance of the series motor in
     ohms
rf=0.2;//field resistance of the series motor in
    ohms
i=60;//current taken by the motor in amperes
w=90;//speed of the motor in rad/s
r0=0.4;//resistance added in parallel with the field
     in ohms

//calculations
//it is assumed that flux is proportoinal to the
    field current and load is constant
```

```
E1=v-(i*(rf+ra));//motor e.m.f. in volts
I=i/((r0/(r0+rf))^0.5);//current in amperes
E2=v-(I*ra)-((I*rf)*(r0/(r0+rf)));//new motor e.m.f. in volts
W=(E2/E1)*(i/I)*((r0+rf)/r0)*w;//increased speed of the motor in rad/s

//output
mprintf('with resistor connected the speed of the motor will increase to %3.0f rad/s',W)
```

Chapter 4

the single phase a c series circuit

Scilab code Exa 4.1 finding the current taken by the coil

```
clc
clear

//input
r=10;//resistance of a coil in ohms
l=0.08;//inductance of the coil in henry
v=250;//a.c. supply voltage in volts
f=50;//supply frequency in hertz

//calculations
Xl=2*%pi*f*l;//reactance of the coil in ohms
z=((r^2)+(Xl^2))^0.5;//impedance of the circuit
I=v/z;//current in amperes
phi=acos(r/z);// phase angle in radians
PHI=(phi*180)/%pi;//phase angle in degrees

//output
mprintf('the coil will take a current of %3.2f A
   lagging by %3.0f degree on the voltage',I,PHI)
```

Scilab code Exa 4.2 finding the phase angle and magnitude of current

```
clc
clear

//input
r=12;//resistance connected in series with a coil in ohms
rc=4;//resistance of the coil in ohms
l=0.02;//inductance of the coil in henry
v=230;//a.c. supply voltage in volts
f=50;//frequency of the supply in hertz

//calculations
R=r+rc;//total resistance of circuit in ohms
xl=2*%pi*f*l;//reactance of the coil in ohms
z=((R^2)+(xl^2))^0.5;//impedance of the circuit in ohms
i=v/z;//current in amperes
phi=(acos(r/z))*(180/(2*%pi));//angle of phase difference in degrees
vr=i*r;//voltage drop across resistor in volts
vc=i*(((rc^2)+(xl^2))^0.5);//voltage drop across coil in volts

//output
mprintf('the current taken from the supply is %3.1f A lagging by %3.1f degree.\n the voltage drops across the resistor and the coil are %3.0f V and %3.0f V',i,phi,vr,vc)
```

Scilab code Exa 4.3 finding required components of a coil

```
clc
clear

//input
r1=10;//resistance of first coil in ohms
l1=0.05;//inductance of first coil in henry
v1=150;//limit of voltage drop across of first coil
    in volts
v=240;//supply a.c. voltage in volts
f=50;//frequency of supply in hertz
a=40;//angle by which current lags the combined
    circuit after adding another coil to the first
    coil in series in degrees

//calculations
R=2*%pi*f*l1;//reactance of first coil in ohms
z=((r1^2)+(R^2))^0.5;//impedance of the first coil
    in ohms
i=v1/z;//maximum safe current in amperes
Z=v/i;//total impedance in ohms
Rt=Z*cos(a*(%pi/180));//total resistance in ohms
r2=Rt-r1;//resistance of the second coil in ohms
xt=Z*sin(a*(%pi/180));//total reactance in ohms
x2=xt-R;//reactance of the second coil in ohms
l2=x2/(2*%pi*f);//inductance of the second coil in
    henry
L=l2*1000;//inductance of the second coil in
    millihenry

//output
mprintf('the second coil must have a resistance of
    %3.1f ohm and an inductance of %3.1f mH',r2,L)
```

Scilab code Exa 4.4 finding the resistance and inductance of a coil

```
clc
clear

//input
//given voltage and  current equations are v=354*(
    sin(314*t)) volts ,i=14.1*(sin((314*t)-0.5))
    amperes
vmax=354;//maximum voltage in volts
imax=14.1;//maximum current in amperes
phi=0.5;//phase angle in radians
f=50;//supply frequency in hertz

//calculations
V=0.707*vmax;//voltmeter reading placed in the
    circuit
I=0.707*imax;//ammeter reading placed in circuit
z=V/I;//impedance of the coil in ohms
R=z*cos(phi);//resistance in ohms
xl=z*sin(phi);//reactance of coil in ohms
l=(xl/(2*%pi*f))*1000;//inductance of the coil in
    millihenry

//output
mprintf('the coil has a resistance of %3.0f ohm and
    an inductance of %3.0f mH \n the instrument
    readings will be %3.0f V and %3.0f A',R,l,V,I)
```

Scilab code Exa 4.5 calculation of required capacitance

```
clc
clear

//input
i=0.5;//current taken by filament of an electric
    lamp in amperes
```

```
v1=110;//supply voltage in volts
v2=240;//changed supply in volts
f=50;//supply frequency in hertz

//calculations
z=v2/i;//impedance in ohms
r=v1/i;//resistance of the lamp
xc=((z^2)-(r^2))^0.5;//reactance of the capacitor added to the lamp in series in ohms
c=(10^6)/(2*%pi*f*xc);//capacitance in microfarad
//this can also be solved using phasor diagram

//output
mprintf('the required value of the capacitance is %3.1f microfarad',c)
```

Scilab code Exa 4.6 determination of current and voltage

```
clc
clear

//input
r=10;//resistance of an inductor in ohms
l=0.08;//inductance in henry
c=200*(10^-6);//capacitence of the capacitor connected in series to the inductor in farad
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
xl=2*%pi*f*l;//reactance of the inductor in ohms
xc=1/(2*%pi*f*c);//reactance of the capacitor in ohms
R=xl-xc;//total reactacne of the circuit in ohms
z=((r^2)+(R^2))^0.5;//impedance of the circuit in
```

```
ohms
I=v/z;//current in ohms
phi=(180/%pi)*acos(r/z);//phase angle in degrees
pd=I*(((r^2)+(xl^2))^0.5);//p.d. across inductor in volts

//output
mprintf('the current taken from the supply is %3.1f A lagging on the voltage by %3.1f degrees and the voltage drop across the inductor is %3.0f V',I,phi,pd)
```

Scilab code Exa 4.7 determination of voltage equation

```
clc
clear

//input
r0=15;//resisance added in series wiht an inductor and capacitor in ohms
rl=5;//resistance of the inductor in ohms
l=0.03;//inductance of the inductor in henry
c=250*(10^-6);//capacitance in farad
//i=14.5sin(314t) is the given current expression
w=314;//from the current expression
im=14.5;//from the current expression

//calculations
xl=w*l;//reactance of coil in ohms
xc=1/(w*c);//reactance of capacitor in ohms
r=r0+rl;//total resistance in ohms
R=xc-xl;//total reactance in ohms
z=((r^2)+(R^2))^0.5;//impedance in ohms
vm=im*z;//maximum voltage in volts
phi=acos(r/z);//phase angle in radians
```

```
//output
mprintf('the supply voltage will be V= %3.0f sin((%3
    .0f t)- %3.3f)',vm,w,phi)
```

Scilab code Exa 4.8 finding frequency and potential differences

```
clc
clear

//input
r=12;//resistance of the coil in ohms
l=0.08;//inductance of the coil in henry
c=150*(10^-6);//capacitance of capacitor connected
    in series in farad
v=240;//supply voltage in volts
i=20;//desired current in amperes

//calculations
z=v/i;//impedance in ohms
w=((1/(l*c))^0.5);//angular frequency in rad/sec
f=w/(2*%pi);//frequency required in hertz
xl=w*l;//inductive reactance in ohms
pdc=xl*i;//p.d. across the capacitor in volts
pd=i*(((r^2)+(xl^2))^0.5);//p.d. across the coil

//ouput
mprintf('the frequency at which the current will be
    20A is %3.0f Hz and at this frequency the p.d.s
    across the coil and across the capacitor will be
    %3.0f V and %3.0f V respectively',f,pd,pdc)
```

Scilab code Exa 4.9 calculation of required capacitance

```
clc
clear

//input
f=100000;//frequency in hertz
r=5;//resistance of the coil in ohms
l=0.0016;//inductance of the coil in henry

//calculations
xl=2*%pi*f*l;//inductive reactance of the coil in
    ohms
c=(10^12)/(2*%pi*f*xl);//capacitance required for
    resonance in pico farad

//output
mprintf('the series capacitor must be turned to %3.0
    f pF to produce resonance at 100kHz',c)
```

Scilab code Exa 4.10 calculations of required frequency and currents

```
clc
clear

//input
r=1;//resistance of the coil in ohms
l1=10*(10^-6);//inductance of coil in henry
c1=1*(10^-6);//capacitor which is connected in
    series with the coil in farad
l2=20*(10^-6);//changed inductance in henry
c2=0.5*(10^-6);//changed capacitance in farad
v=10;//supply volts in volts

//calculations
f0=1/(2*%pi*((l1*c1)^0.5));//resonant frequency in
    hertz
```

```
F0=0.9*f0;//required resonant frequency in hertz
xl1=2*%pi*F0*l1;//inductive reactance in ohms
xc1=1/(2*%pi*F0*c1);//capacitive reactance in ohms
X=xc1-xl1;//effective reactance in ohms
z=((r^2)+(X^2))^0.5;//impedance in ohms
i=v/z;//current in ohms
xl2=2*%pi*f0*l2;//new inductive reactance in ohms
xc2=xl2;// at resonance
xl3=0.9*xl2;//inductive reactacne at lower frequency
    in ohms
xc3=xc2/0.9;//inductive capacitance at lower
   frequency in ohms
X1=xc3-xl3;//effective reatance in ohms
I=v/X1;//current in amperes

//output
mprintf('the value of the current at 0.9*resonant
   frequency is %3.2f A and at lower frequency with
   change in values of inductance and capacitance is
    %3.0f A',i,I)
```

Scilab code Exa 4.11 calculation of ratio between the pd and supply voltage

```
clc
clear

//input
c=200*(10^-12);//capacitance of a capacitor which is
    connected in series with a coil in farad
q=80;//Q factor
v=0.250;//supply voltage in volts
f=500000;//supply frequecy in hertz

//calculations
```

```
pd=q*v;//p.d. across the capacitor in volts
ic=pd*2*%pi*f*c;//capacitor current in amperes
r=v/ic;//resistance of the coil in ohms
xl=q*r;//reactance of coil in ohms
l=(xl/(2*%pi*f))*(10^6);//inductance of the coil in ohms

//output
mprintf('the resistance and the inductance of the coil are %3.1f ohms and %3.0f microH respectively',r,l)
```

Scilab code Exa 4.12 determination of inductance and phase angle of the coil

```
clc
clear

//input
q=100;//Q factor of a coil
r=25;//resistance of the coil in ohms
//a capacitor is connected in sries with the coil
f=400000;//resonant frequency in hertz
i=0.125;//current at resonance in amperes

//calculations
p=i*i*r;//power dissipated in coil in watts
e=p/f;//energy dissipated per cycle in joules
im=(2*i)^0.5;//assumin sinusoidal current in maperes
l=(((q*p)/(2*%pi*f))*(2/(im^2)))*1000;//inductance in millihenry
phi=acos(1/q);//phase angle in radians
c=(10^12)/(2*%pi*f*r*q);//capacitance in picofarad

//output
```

```
mprintf('the inductance and the phase angle of the
    coil are %3.1f mH and %3.2f radians and the
    required capacitance for resonance is %3.0f pF',l
    ,phi,c)
```

Chapter 5

the single phase ac parallel circuit

Scilab code Exa 5.1 determining the current taken from the supply

```
clc
clear

//input
r=20;//pure resistance connected in parallel with a pure inductance in ohms
l=0.08;//pure inductance in henry
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
i1=v/r;//current in resistive branch in amperes
i2=v/(2*%pi*f*l);//current inductive branch in amperes
it=((i1*i1)+(i2*i2))^0.5;//total current in amperes
phi=(180/%pi)*acos(i1/it);//phase angle in degrees

//output
mprintf('the total current is %3.1f A lagging by %3
```

```
.1f degree',it,phi)
```

Scilab code Exa 5.2 finding current and phase angle

```
clc
clear

//input
r=25;//resistance of a non inductive resistor in ohms
rl=10;//resistance of the inductor
l=0.06;//inductance of the inductor in henry
//non inductive resistor and resistive inductor are connected in parallel
v=230;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
i1=v/r;//current in resistive branch in amperes
i2=v/(((rl*rl)+((2*%pi*f*l)^2))^0.5);//current is reactive-resistive branch in amperes
phi=acos(rl/(2*%pi*f*l));//phase angle in radians
it=i1+(i2*cos(phi));//total in-phase component in amperes
iq=i2*sin(phi);//total quadrature component in amperes
I=((it*it)+(iq*iq))^0.5;//resultant current in amperes
phit=(180/%pi)*acos(it/I);//phase angle in degrees

//output
mprintf('the total current is %3.1f A lagging by %3.0f degrees',I,phit)
```

Scilab code Exa 5.3 calculation of current taken from the supply

```
clc
clear

//input
//coils a and b in connected in parallel
v=240;//supply voltage in volts
f=50;//supply frequency in hertz
ra=10;//resistance of coil a in ohms
xla=25;//inductive reactance of coil a in ohms
rb=20;//resistance of coil b in ohms
xlb=12;//inductive reactance of coil b in ohms

//calculations
z1=((ra^2)+(xla^2))^0.5;//impedance of coil a in
    ohms
i1=v/z1;//current in coil a in amperes
cos1=ra/z1;//cosine of phase angle1
sin1=xla/z1;//sine of phase angle1
z2=((rb^2)+(xlb^2))^0.5;//impedance of coil b in
    ohms
i2=v/z2;//current in coil b in amperes
cos2=rb/z2;//cosine of phase angle2
sin2=xlb/z2;//sine of phase angle2
ii=(i1*cos1)+(i2*cos2);//total in phase component in
     amperes
iq=(i1*sin1)+(i2*sin2);//total quadrature component
    in amperes
I=((ii^2)+(iq^2))^0.5;//total current in amperes

//output
mprintf('the total current is %3.1f A',I)
```

Scilab code Exa 5.4 calculation of reactance and inductance

```
clc
clear

//input
i=10;//total current taken by two−branch parallel
    circuit in amperes
a=37*(%pi/180);//phase angle by which current lags
    by on the voltage in degrees
v=100;//voltage supply in volts
f=50;//frequency of supply in hertz
g1=0.03;//conductance of first branch in siemens
b1=0.04;//inductive susceptance of first branch in
    siemens

//calculations
gt=(i*cos(a))/v;//total conductance in siemens
bt=(i*sin(a))/v;//total susceptance in siemens
g2=gt-g1;//conductance of second branch in siemens
b2=bt-b1;//susceptance of second branch in siemens
y2=((g2^2)+(b2^2))^0.5;//admittance of second branch
r2=g2/(y2^2);//resistance of second branch in ohms
x2=b2/(y2^2);//reactacne of second coil in ohms
l2=(1000*x2)/(2*%pi*f);//inductance of second coil
    in millihenry

//output
mprintf('the resistance and inductance of second
    branch are %3.2f ohm and %3.2f mH',r2,l2)
```

Scilab code Exa 5.5 determination of total current and phase angle in rc parallel circuit

```
clc
clear

//input
r=30;//resistance of a resistance in ohms which is
    connected in parallel with a bank of capacitors
c=80*(10^-6);//capacitance of bank of capacitors in
    farad
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
i1=v/r;//current in phase with the voltage in
    amperes
i2=v*2*%pi*f*c;;//current leading on voltage by 90
    degrees in amperes
i=((i1^2)+(i2^2))^0.5;//total current in amperes
phi=(180/%pi)*acos(i1/i);//phase angle in degrees

//output
mprintf('the total current is %3.0f A leading on the
    voltage by %3.0f degrees',i,phi)
```

Scilab code Exa 5.6 calculation of current using admittance method

```
clc
clear

//input
v=415;//supply voltage in volts
f=50;//supply frequency in hertz
r1=50;//resistance in branch 1 in ohms
```

```
r2=30;//resistance in branch 2 in ohms
c=50*(10^-6);//capacitance in branch 2 in farad
//branch 1 and 2 are in parallel

//calculations
g1=1/r1;//conductance of branch 1 in siemens
xc=1/(2*%pi*f*c);//reactance of branch 2 in siemens
z=((r2^2)+(xc^2))^0.5;//impedance in ohms
g2=r2/(z^2);//conductance of branch 2 in siemens
b2=xc/(z^2);//susceptance of branch 2 in siemens
gt=g1+g2;//total conductance in siemens
bt=0+b2;//total susceptance in siemens
yt=((gt^2)+(bt^2))^0.5;//total admittance in mho
it=v*yt;//total current in amperes
R=gt/(yt^2);//resistance of the series equivalent circuit in ohms
Xc=bt/(yt^2);//capacitive reactance of the series circuit in ohms

//output
mprintf('the current taken from the supply will be %3.1f A and the resistance and capacitive reactance of the equivalent series circuit are %3.0fohm and %3.0fohms respectively',it,R,Xc)
```

Scilab code Exa 5.7 finding current taken from the supply by an rlc parallel circuit

```
clc
clear

//input
r=32;//resistance in branch 1 in ohms
l=0.08;//inductance in branch 2 in henry
c=200*(10^-6);//capacitance in branch 3 in farad
```

```
//braches 1,2 and 3 are in parallel
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
g1=1/r;//conductance of branch 1 in siemens
b2=-1/(2*%pi*f*l);//susceptance of branch 2 in
   siemens
b3=2*%pi*f*c;//susceptance of branch 3 in siemens
bt=b2+b3;//total susceptance in siemens
yt=((g1^2)+(bt^2))^0.5;//total admittance in mho
it=v*yt;//total current in amperes
phi=(180/%pi)*acos(g1/yt);//phase angle in degrees

//output
mprintf('the total current will be %3.2f A leading
   on the voltage by %3.1f degrees',it,phi)
```

Scilab code Exa 5.8 calculation of total current and phase angle

```
clc
clear

//input
r1=100;//resistance in branch 1 in ohms
r2=10;//resistance in branch 2 in ohms
l2=0.07;//inductance in branch 2 in henry
r3=10;//resistance in branch 3 in ohms
c3=100*(10^-6);//capacitance in branch 3 in farad
//branches 1,2 and 3 are in parallel with each other
v=250;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
it=v/r1;//total current in branch 1 in amperes
```

```
ii1=it;//since resistive branch
iq1=0;//since resistive branch
z2=((r2^2)+((2*%pi*f*l2)^2))^0.5;//impedance of
    branch 2 in ohms
i2=v/z2;//current in branch 2 in amperes
cos2=r2/z2;//cosine of phase angle
phi2=(180/%pi)*acos(cos2);//phase angle in degree
ii2=i2*cos2;//in phase component of branch2 in
    amperes
iq2=-i2*sin(acos(cos2));//quadrature component of
    branch 2 in amperes
z3=((r3^2)+((1/(2*%pi*f*c3))^2))^0.5;//impedance of
    branch 3 in ohms
i3=v/z3;//current in branch 3 in amperes
cos3=r3/z3;//cosine of the phase angle
phi3=(180/%pi)*acos(cos3);//phase angle in degrees
ii3=i3*cos3;//in phase component of branch 3 in
    amperes
iq3=i3*sin(acos(cos2));//quadrature component of
    branch 3 in amperes
ii=ii1+ii2+ii3;//total in phase component in amperes
iq=iq1+iq2+iq3;//total quadrature component in
    amperes
it=((ii^2)+(iq^2))^0.5;//total current in amperes
cost=ii/it;//cosine of total phase angle
phit=(180/%pi)*acos(cost);//phase angle in degrees
zs=v/it;//equivalent series impedance in ohms
rs=zs*cost;//equivalent series resistance in ohms
xs=zs*sin(acos(cost));//equivalent series reactance
    in ohms
l=(xs*1000)/(2*%pi*f);//inductance in millihenry

//output
mprintf('the total current is %3.2f A lagging by %3
    .0f degrees and the equivalent series circuit
    would be a resistive inductive circuit of %3.1f
    ohms and %3.0f mH',it,phit,rs,l )
```

Scilab code Exa 5.9 finding resonant frequency

```
clc
clear

//input
r=10;//resistance of an inductor in ohms
l=0.08;//inductance of an inductor in henry
c=150*(10^-6);//capacitance by which the inductor is
    shunted in farad
v=240;//supply voltage in volts

//calculation
z1=l/c;//impedance in henry
f0=(1/(2*%pi))*(((z1-(r^2))/(l^2))^0.5);//resonant
   frequency in hertz
z=((r^2)+((2*%pi*f0*l)^2))^0.5;//impedance in ohms
it=(v*r)/(z^2);//total current in amperes

//output
mprintf('the circuit will be in current resonance at
    a frequency of %3.1f Hz and at this frequency
   the supply current will be %3.1f A',f0,it)
```

Scilab code Exa 5.10 calculation of ratio between capacitor current and supply current

```
clc
clear

//input
r=2;//resistance of an inductor in ohms
```

```
l=0.07;//inductance of an inductor in henry which is in resonance with a capacitor
f=60;//resonant frequency in hertz

//calculations
tanphi=(2*%pi*f*l)/r;//ratio between capacitor current and supply current

//output
mprintf('the ratio of capacitor current to supply current is %3.1f : 1',tanphi)
```

Scilab code Exa 5.11 calculation of resistance and inductance of load

```
clc
clear

//input
c=4*(10^-6);//capacitance of a capacitor by which a resistive-inductive load is shunted in farad
v=2;//supply voltage in volts
f=5000;//supply frequency in hertz
q=10;//Q factor of the circuit

//calculations
vwc=2*2*%pi*f*c;//capacitor current in amperes
it=vwc/q;//total current in amperes
i1=((vwc^2)+(it^2))^0.5;//load current in amperes
z1=v/i1;//load impedance in ohms
r1=z1*(it/i1);//resistance of load in ohms
x1=q*r1;//reactance of load in ohms
l=(x1*(10^6))/(2*%pi*f);//load inductance in microhenry

//output
```

```
mprintf('the load has a resistance of %3.3f ohms and
    an inductance of %3.0f microhenry',r1,l)
```

Chapter 6

operational methods

Scilab code Exa 6.1 calculation of current taken from the supply and its phase angle

```
clc
clear

//input
z=7.5+(%i*10);//impedance connected to a supply in
   ohms
r=7.5;//resistance from impedance in ohms
x=10;//reactance from impedance in ohms
v=200;//supply voltage in volts

//calculations
i=v/z;//current taken from supply in amperes
I=(((real(i))^2)+((imag(i))^2))^0.5;//current
   magnitude in amperes
phi=(180/%pi)*atan(-x/r);//phase angle in degrees
PHI=-phi;//lag

//output
mprintf('the supply current is %3.0f A lagging on
   the voltage by %3.0f',I,PHI)
```

Scilab code Exa 6.2 calculation of supply current and voltages and phse angle

```
clc
clear

//input
z1=5+(%i*5);//impedance 1 in ohms
z2=10-(%i*15);//impedance 2 in ohms
//impedances 1 and 2 are in series
v=240;//supply voltage in volts

//calculations
zt=z1+z2;//total impedance in ohms
i=v/zt;//current taken in amperes
v1=z1*i;//voltage 1 in volts
V1=(((real(v1))^2)+((imag(v1))^2))^0.5;//voltage
    magnitude in volts
phi1=(180/%pi)*atan((imag(v1))/(real(v1)));//phase
    angle 1 in degrees
v2=i*z2;//voltage 2 in volts
V2=(((real(v2))^2)+((imag(v2))^2))^0.5;//voltage
    magnitude in volts
phi2=(180/%pi)*atan(-(imag(v2))/(real(v2)));//phase
    angle 2 in degrees
I=(((real(i))^2)+((imag(i))^2))^0.5;//current
    magnitude in amperes

//output
mprintf('the supply current is%3.1f A and the two
    voltages are %3.0f V and %3.0f V leading by %3.1f
     degrees and lagging by %3.1f degrees
    respectively',I,V1,V2,phi1,phi2)
```

Scilab code Exa 6.3 calculation of total impedance and the current

```
clc
clear

//input
z1=12+(%pi*16);//impedance 1 in ohms
z2=10-(%i*10);//impedance 2 in ohms
//impedances 1 and 2 are in parallel
v=240;//supply voltage in volts

//calculations
zt=(z1*z2)/(z1+z2);//total impedance in ohms
Z=(((real(zt))^2)+((imag(zt))^2))^0.5;//current
    magnitude in amperes
i=v/zt;//supply current in amperes
I=(((real(i))^2)+((imag(i))^2))^0.5;//current
    magnitude in amperes

//output
mprintf('the magnitude of total impedance is %3.1f
    ohms and of the supply current is %3.1f A',Z,I)
```

Scilab code Exa 6.4 caculation of current taken by a combination

```
clc
clear

//input
r1=10;//resistance of branch 1 in ohms
l1=0.08;//inductance of branch 1 in henry
r2=20;//resistance of branch 2 in ohms
```

```
c2=150*(10^-6);//capacitance of branch 2 in farad
//branch 1 and 2 are in parallel
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
xl=2*%pi*f*l1;//reactance of branch 1 in ohms
z1=r1+(%i*xl);//impedance of branch 1 in ohms
y1=1/z1;//admittance of branch 1 in mho
x2=1/(2*%pi*f*c2);//reactane of branch 2 in ohms
z2=r2-(%i*x2);//impedance of branch 2
y2=1/z2;//admittance of branch 2 in mho
yt=y1+y2;//total admittance in mho
it=v*yt;//supply current in amperes
I=(((real(it))^2)+((imag(it))^2))^0.5;//current
    magnitude in amperes

//output
mprintf('the current taken from the supply is %3.2f
    A',I)
```

Scilab code Exa 6.5 calculation of current and phase angle

```
clc
clear

//input
r=20;//resistance of an inductor in ohms
x=15;//reactance of an inductor in ohms
v=250;//supply voltage in volts

//calculations
z=((r^2)+(x^2))^0.5;//magnitude of impedance in ohms
phi=(180/%pi)*atan(x/r);//phase angle in degrees
i=v/z;//current magnitude in amperes
```

```
//output
mprintf('the current will be %3.0f A lagging by %3.0
   f degrees',i,phi)
```

Scilab code Exa 6.6 finding magnitude and phase angle of the voltage

```
clc
clear

//input
i=8-(%i*6);//current flowing in amperes
z=10+(%i*10);//impedance in ohms

//calculations
I=(((real(i))^2)+((imag(i))^2))^0.5;//current
   magnitude in amperes
Z=(((real(z))^2)+((imag(z))^2))^0.5;//magnitude of
   impedance in ohms
phi1=(180/%pi)*atan(-(imag(i))/(real(i)));//phase
   angle of current in degrees
phi2=(180/%pi)*atan(-(imag(z))/(real(z)));//phase
   angle of impedance in degrees
phi=-(phi2+phi1);
v=I*Z;//voltage across coil in volts

//output
mprintf('the voltage across the coil is %3.0f V
   leading by %3.0f degrees',v,phi)
```

Scilab code Exa 6.7 calculating the components of equivalent series circuit

```
clc
clear

//input
z1=10+(%i*15);//first impedance in ohms
z2=15-(%i*25);//second impeddance in ohms
//impedances 1 and 2 are connected in parallel

//calculations
Z1=(((real(z1)^2)+(imag(z1)^2)))^0.5;//magnitude of impedance 1 in ohms
Z2=(((real(z2)^2)+(imag(z2)^2)))^0.5;//magnitude of impedance 2 in ohms
phi1=(180/%pi)*atan((imag(z1))/real(z1));//phase angle 1 in degrees
phi2=(180/%pi)*atan((imag(z2))/real(z2));//phase angle 1 in degrees
Z=z1+z2;//total impedance in ohms
Zt=(((real(Z)^2)+(imag(Z)^2)))^0.5;//magnitude of total impedance in ohms
PHIt=(180/%pi)*atan((imag(Z))/real(Z));//total phase angle in degrees
ZT=(Z1*Z2)/Zt;//magnitude of equivalent impedance in ohms
PHIT=phi1+phi2-PHIt;//phase angle of equivalent impedance in degrees
p=(PHIT*%pi)/180;// phase angle in radians
Zs=(ZT*cos(p))+(%i*(ZT*sin(p)));//series impedance in ohms
R=real(Zs);//resistance of equivalent series circuit in ohms
X=imag(Zs);//reactance  of equivalent series circuit in ohms

//output
mprintf('the resistance and inductive reactance of equivalent series circuit are %3.1f ohm and %3.2f ohm',R,X)
```

Scilab code Exa 6.8 finding the magnitude and phase angle of current

```
clc
clear

//input
y1=0.01-(%i*0.03);//first admittance in mho
y2=0.05+(%i*0);//second admittance in mho
y3=%i*0.05;//third admittance in mho
//three admittances are connected in parallel
v=250;//supply voltage in volts

//calculations
y=y1+y2+y3;//total admittance in mho
Y=(((real(y)^2)+(imag(y)^2)))^0.5;//magnitude of
    total admittance in mho
phi=(180/%pi)*atan((imag(y))/(real(y)));//phase
    angle in degrees
i=v*Y;//current in amperes

//output
mprintf('the total current is %3.1f A leading on the
     voltage by %3.1f degrees',i,phi)
```

Chapter 7

power and power factor

Scilab code Exa 7.1 finding the average and instantaneous power

```
clc
clear

//input
r=20;//resistance of coil in ohms
l=0.04;//inductance of coil in henry
v=240;//supply voltage in volts
f=50;//frequency of supply in hertz

//calculations
xl=2*%pi*f*l;//reactance of coil in ohms
z=((r^2)+(xl^2))^0.5;//impedance of coil in ohms
i=v/z;//current in amperes
cosp=r/z;//cosine of phase angle
Pavg=v*i*cosp;//average power in watts
pmax=v*i*(cosp+1);//maximum instantaneous power in watts

//ouput
mprintf('the average power and the maximum instantaneous power in the coil are %3.0f W and
```

```
    %3.0f W respectively',Pavg,pmax)
```

Scilab code Exa 7.2 finding the time elapsed before maximum power

```
clc
clear

//input
//given e.m.f. equation is e=340sin(314t)V and
    current equation is i=12sin(314t-0.7)A
t=0.0015;//time in seconds after which the e.m.f. is
     zero and increasing positively
vm=340;//maximum voltage in volts from voltage
    equation
im=12;//maximum current in amperes from current
    equation
phi=0.7//phase angle from current equation
w=314;//from voltage and current equations

//calculations
//when t=0.0015 seconds
p=vm*sin(w*t)*im*sin((w*t)-phi);//power in watts
pmax=(vm*im*((cos(phi))+1))/2;//maximum power in
    watts
T=(((acos(((2*pmax)/(vm*im))-(cos(phi))))+phi)
    *(1000))/(2*w);//time interval in milliseconds

//output
mprintf('at a time of 1.5mS after the specified
    instant the power was %3.0f W and the maximum
    power occured %3.1f mS after the same specified
    instant',p,T)
```

Scilab code Exa 7.3 calculation of apparent and reactive powers and the inductance of coil

```
clc
clear

//input
zl=20;//impedance of the inductor in ohms
pf=0.45;//lagging power factor
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
i=v/zl;//current taken by the inductor in amperes
p=v*i*pf;//true power in the circuit in watts
pa=v*i;//apparent power in VA
pr=v*i*sin(acos(pf));//reactive power in var
r=p/(i*i);//resistance in ohms
xl=((zl^2)-(r^2))^0.5;//reactance in ohms
l=(xl*1000)/(2*%pi*f);//inductance in millihenry

//output
mprintf('the wattmeter will read %3.0f W \n the
    apparent and the reactive powers are %3.0f VA and
     %3.0f var respectively \n the inductance of the
    inductor is %3.0f mH',p,pa,pr,l)
```

Scilab code Exa 7.4 finding the total kVA loading and overall power factor

```
clc
clear

//input
d1=400;//load in kW at unity power factor
d2=1000;//load in kVA at a lagging power factor
```

```
d3=500;//load in kVA at a leading power factor
pf1=1;//unity power factor
pf2=0.71;//lagging power factor
pf3=0.8;//leading power factor

//calculations
pa=d1+(d2*pf2)+(d3*pf3);//total active power loading in watts
pr=(d2*pf2)-(d3*sin(acos(pf3)));//total reactive power in var
pk=(((pa^2)+(pr^2))^0.5)/1000;//total MVA loading
pf=pa/(pk*1000);//total power factor

//output
mprintf('the total load on the sub-station is %3.2f MVA at a lagging power factor of %3.3f ',pk,pf)
```

Scilab code Exa 7.5 finding total active power taken from the supply

```
clc
clear

//input
rl=10;//resistance of an inductor in ohms
l=0.05;//inductaance of an inductor in henry
rc=20;//resistance in series with a capacitor in ohms
c=150*(10^-6);//capacitance of a capacitor in farad
///inductor is in parallel with the series circuit containing a resistor and a capacitor
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
xl=2*%pi*f*l;//inductive reactance in ohms
```

```
z1=((rl^2)+(xl^2))^0.5;//impedance of the inductor
   in ohms
i1=v/z1;//current in inductor in amperes
phi1=rl/z1;//power factor of inductor
xc=1/(2*%pi*f*c);//capacitive reactance in ohms
z2=((rc^2)+(xc^2))^0.5;//impedance of series circuit
    in ohms
i2=v/z2;//current in series circuit in amperes
phi2=rc/z2;//power factor of series circuit
i=(i1*phi1)+(i2*phi2);//total in phase component in
   amperes
P=(v*i);//total power in watts

//output
mprintf('the active power taken from the supply is
   %3.0f W',P)
```

Scilab code Exa 7.6 calculation of total power and current taken form the supply using admittance method

```
clc
clear

//input
ra=5;//resistance of inductor in branch a in ohms
la=0.08;//inductance of the inductor in branch a in
   henry
rb=15;//resistance in branch 2 in ohms
cb=100*(10^-6);//capacitance in branch b in farad
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
//branches a and b are in parallel with supply
xa=2*%pi*f*la;//inductive reactance in ohms
```

```
za=((ra^2)+(xa^2))^0.5;//impedance in branch a in
    ohms
xc=1/(2*%pi*f*cb);//capacitive reactance in ohms
zb=((rb^2)+(xc^2))^0.5;//impedance in branch b in
    ohms
g=(ra/(za^2))+(rb/(zb^2));//total conductance in
    siemens
b=(-xa/(za^2))+(xc/(zb^2));//total susceptance in
    siemens
y=((g^2)+(b^2))^0.5;//total admittance in siemens
i=v*y;//total current in amperes
p=v*v*g;//total power taken from the supply in watts

//output
mprintf('the total current and power taken from the
    supply are %3.2f A and %3.0f W',i,p)
```

Scilab code Exa 7.7 finding required range of frequency

```
clc
clear

//input
r=10;//resistacne of an acceptor circuit in ohms
l=0.08;//inductance of an acceptor circuit in henry
c=1250*(10^-12);//capacitance of an acceptor circuit
     in faraf
v=1.5;//supply voltage in volts
//average power dissipated in not less tha half of
    power at resonance

//calcultions
i=v/r;//current in amperes
p=i*i*r;//power in watts
pmin=p*0.5;//minimum average power in watts
```

```
i1=pmin/r;//current in amperes
z1=v/i1;//impedance in ohms
x=((z1^2)-(r^2))^0.5;//effective reactance in ohms
//on equating xc and xl we get equation for frequency as -(502*(10^-6))(f^2)-10f+127.2(10^6)=0
a= -502*(10^-6);//from the above equation
b= -10;//from the above equation
c=127.2*(10^6);//from the above equation
f2=(((b-(((b^2)-(4*a*c))^0.5))/(2*a)))/1000;//upper frequency in hertz
f1=((((-b)-(((b^2)-(4*a*c))^0.5))/(2*a)))/1000;//lower frequency in hertz

//output
mprintf('the frequency range over which the average power doesnot fall below 0.5*the average power at resonance is %3.0f kHz and %3.0f kHz',f1,f2)
```

Scilab code Exa 7.8 calculation of required capacitance

```
clc
clear

//input
d=125;//power taken by an industrial load in kilowatts
pf=0.6;//power factor
v=415;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
phii=acos(pf);//initial phase angle in radians
kVAo=d/pf;//original kVA
kvaro=d*tan(phii);//original kvar
```

```
//for 0.9power factor
phif=acos(0.9);//phase angle in radians
kvarf=d*tan(phif);//final kvar
kvarc=kvaro-kvarf;//capacitor kvar
c1=(kvarc*(10^3)*(10^6))/(v*v*2*%pi*f);//capacitance
    in microfarad
kVAf=d/0.9;//final kVA
kVAr=kVAo-kVAf;//reduction in kVA
//for unity power factor
kvarC=kvaro;//capacitor kvar
c2=(kvarC*(10^3)*(10^6))/(v*v*2*%pi*f);//capacitance
    in microfarad
kVAF=d;//final kVA
kVAR=kVAo-kVAF;//reduction in kVA

//output
mprintf('the required values of capacitance are %3.0
   f uF and %3.0f uF and the respective savings in
   kVA are %3.1f kVA and %3.1f kVA',c1,c2,kVAr,kVAR
   )
```

Scilab code Exa 7.9 calculation of required capacitance

```
clc
clear

//input
d=75;//load at lagging powerfactor in kW
pf=0.75;//lagging power factor
v=1100;//supply voltage in volts
f=50;//frequency in hertz
d0=10;//desired increment in load in kW

//calculations
kVAi=d/pf;//initial kVA
```

```
cos2=(d+d0)/kVAi;//final power factor
phi1=acos(pf);
phi2=acos(cos2);
kvarc=kVAi*(d0)*(sin(phi1)-sin(phi2));//capacitor
    kvar
c=(kvarc*(10^3)*(10^6))/(v*v*2*%pi*f);//capacitance
    required in microfarad

//output
mprintf('the power factor has to be increased to %3
    .2f lag and the value of capacitance required is
    %3.0f uF',cos2,c)
```

Scilab code Exa 7.10 calculation of pure resistive load for maximum power

```
clc
clear

//input
v=3.3;//voltage rating of an alternator in kV
ri=3;//internal resistance of alternator in ohms
xl=32;//series inductive reactance in ohms
rc=1;//resistance of a cable in ohms
xc=2;//effective reactance of the cable in ohms

//calculations
R=ri+rc;//resistance of line and alternator in ohms
X=xl+xc;//reactance of line and alternator in ohms
Z=((R^2)+(X^2))^0.5;//impedance of line and
    alternator in ohms
Rl=Z;//required load resistance in ohms
zt=(((Z+R)^2)+(X^2))^0.5;//total impedance of the
    circuit in ohms
I=(v*1000)/zt;//current in amperes
pmax=(I*I*Rl)/1000;//maximum power in load in
```

```
    kilowatts

//output
mprintf('togive a maximum load power of %3.0f kW the
     load must have a resistance of %3.2f ohms',pmax,
    Rl)
```

Scilab code Exa 7.11 calculation of components of a fully variable load

```
clc
clear

//input
r=10;//resistance in source impedance in kiloohms
l=0.005;//inductance in source impedance in henry
v=100;//supply voltage in volts
f=10000;//supply frequency in hertz

//calculations
xl=2*%pi*f*l;//inductive reactance in ohms
c=((10^6)*(10^3))/(2*%pi*f*xl);//capacitance in
    picofarad

//output
mprintf('for maximum power transfer the load must
    consist of %3.0f kilo ohms resistance in series
    with a capacitance of %3.0f pF',r,c)
```

Scilab code Exa 7.12 calculation of power dissipated by the inductor

```
clc
clear

```

```
//input
r=20;//resistance of resistor connected in series
    with inductor in ohms
v=240;//supply voltage in volts
f=50;//supply frequency in hertz
pdr=130;//potential drop across resistor in volts
pdl=170;//potential drop across inductor in volts

//calculations
cosp=((v*v)-(pdr^2)-(pdl^2))/(2*pdr*pdl);//power
    factor
i=pdr/r;//current in amperes
p=pdl*i*cosp;//power in watts

//output
mprintf('the power dissipated by the inductor is %3
    .0f W',p)
```

Scilab code Exa 7.13 calculation of inductance resistance and the power loss

```
clc
clear

//input
r=32;//resistance connected in parallel with an
    inductor in ohms
v=240;//supply voltage in volts
f=50;//supply frequency in hertz
il=8;//current in inductor in amperes
it=14;//total current in amperes

//calculations
ir=v/r;//current in resistor in amperes
cosp=((it^2)-(ir^2)-(il^2))/(2*ir*il);//power factor
```

```
R=(v*cosp)/il;//resistance of inductor in ohms
xl=(v*sin(acos(cosp)))/il;//reactance in ohms
l=(xl*1000)/(2*%pi*f);//inductance in millihenry
p=il*il*R;//power loss in inductor in watts

//output
mprintf('the resistance and the inductance of the
    inductor are %3.2f ohms and %3.0f mH respectively
     and the power loss is %3.0f W',R,l,p)
```

Scilab code Exa 7.14 finding the power for the load and whole circuit

```
clc
clear

//input
i1=9;//current taken by a resistive inductive load
    form supply in amperes
v=250;//supply voltage in volts
f=50;//frequency in hertz
i2=12;//current taken when a resistor is placed in
    parallel with the load in amperes
r=50;//resistance of the resistor placed in parallel

//calculations
ir=v/r;//current through the resistor in amperes
cosp=((i2^2)-(ir^2)-(i1^2))/(2*i1*ir);//power factor
cosP=(ir+(i1*cosp))/i2;//power factor for whole
    circuit
pc=(v*i2*cosP)/1000;//power taken by whole circuit
    in kilowatts
pl=(v*i1*cosp);//power taken by load in watts

//output
mprintf('the values of power and power factor for
```

```
the whole circuit and the load are %3.1f kW:%3.2f
 (lag) and %3.0f W:%3.2f (lag) respectively',pc,
cosP,pl,cosp)
```

Chapter 8

three phase circuits

Scilab code Exa 8.1 finding the phase voltage and line current

```
clc
clear

//input
r=24;//resistance of each of three resistors
   connected in star in ohms
v=415;//3 phase supply in volts

//calculations
vp=v/(3^0.5);//phase voltage in volts
ip=vp/r;//phase current in amperes
il=ip;//for star connection

//output
mprintf('the phase voltage is %3.0f V and the
   current in each line is %3.0f A',vp,il)
```

Scilab code Exa 8.2 finding the line current and the phase angle

```
clc
clear

//input
r=15;//resistance of each of three coils connected
    in star in ohms
l=0.08;//inductance of each of three coils connected
    in star in in henry
v=415;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
zp=((r^2)+((2*%pi*f*l)^2))^0.5;//impedance per phase
    in ohms
il=v/(zp*(3^0.5));//line current in amperes
ip=il;//for star connection
phi=(180/%pi)*acos(r/zp);//phase angle in degrees

//output
mprintf('the line current will be %3.1f A lagging on
    its corresponding phase voltage by %3.0f degrees
    ',il,phi)
```

Scilab code Exa 8.3 calculation of total line current and total phase angle

```
clc
clear

//input
v=415;//3 phase supply voltage in volts
f=50;//supply frequency in hertz
//system is loaded with three star connected coils
    and three star connected resistors
ic=10;//current taken by each of the coils in
    amperes lagging by 60 degrees
```

```
ir=8;//current taken by each of the resistors in amperes
phi=(60*%pi)/180;//lagging phase angle in radians

//calculations
ii=ir+(ic*cos(phi));//sum of in phase components in amperes
iq=(ic*sin(phi));//sum of quadrature components in amperes
i=((ii^2)+(iq^2))^0.5;//total current in amperes
PHI=(180/%pi)*acos(ii/i);//phase angle in degrees

//ouput
mprintf('the total  line current is %3.1f A lagging on the relative phase voltage by %3.1f degrees',i,PHI)
```

Scilab code Exa 8.4 illustration for neutral current is zero

```
clc
clear

//input
//three impedances of resistance and inductive reactance are connected in star
r=20;//resistance in ohms
x=15;//reactance in ohms
v=440;//three phase supply voltage in volts

//calculations
z=((r^2)+(x^2))^0.5;//each impedance in ohms
il=v/((3^0.5)*z);//line current in amperes
ip=il;//for star connections
cosp1=(180/%pi)*acos(r/z);//power factor1 in degrees
cosp2=120+cosp1;//each current is displaced by 120
```

```
degrees
cosp3=240+cosp1;//each current is displaced by 120 degrees
ii=il*((cos(acos(r/z))+cos((120+cosp1)*(%pi/180))+cos((240+cosp1)*(%pi/180)));//total in phase component in amperes
iq=il*-((sin(acos(r/z))+sin((120+cosp1)*(%pi/180))+sin((240+cosp1)*(%pi/180)));//total quadrature component in amperes

//output
mprintf('the the resultant in phase and quadrature components are %3.5fA and %3.5fA respectively\nhence the sum of three balanced currents is zero',ii,iq)
```

Scilab code Exa 8.5 calculation of phase and line currents

```
clc
clear

//input
//three resistors are connected in delta
r=30;//resistance of each resistor in ohms
v=240;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
ip=v/r;//phase current in amperes
il=ip*(3^0.5);//line current in amperes

//output
mprintf('the phase and line currents are %3.0f A and %3.1f A respectively',ip,il)
```

Scilab code Exa 8.6 calculation of line current and phase angle

```
clc
clear

//input
//three impedances are connected in delta each
   containing a resistor and a capacitor
r=15;//resistance in ohms
c=100*(10^-6);//capacitance in farad
v=415;//3phase supply voltage in volts
f=50;//frequency in hertz

//calculations
xc=1/(2*%pi*f*c);//capacitive reactance in ohms
zp=((r^2)+(xc^2))^0.5;//impedance per phase in ohms
ip=v/zp;//phase current in amperes
il=ip*(3^0.5);//line current in amperes
phi=(180/%pi)*acos(r/zp);//leading phase angle in
   degrees

//output
mprintf('the line current is %3.1f A and the phase
   angle is %3.1f lead',il,phi)
```

Scilab code Exa 8.7 determination of line currents and phase angle in two cases

```
clc
clear

//input
```

```
//three impedances are connected in delta each containing a resistor and an inductor
r=25;//resistance in ohms
l=0.06;//inductance in henry
v=415;//3 phase supply voltage in volts
f=50;//supply frequency in hertz
//three capacitors are connected across the same supply in star
c=200*(10^-6);//the capacitance in farad

//calculations
//for delta connection
xl=2*%pi*f*l;//inductive reactance in ohms
zp=((r^2)+(xl^2))^0.5;//impedance per phase in ohms
ip=v/zp;//phase current in amperes
il=ip*(3^0.5);//line current in amperes
//il lags on ip by 30degrees.so the angle between the line current and ilne voltage is 30+phase angle in degrees
phi=30+((180/%pi)*acos(r/zp));//phase angle in degrees
cosp=(r/zp);//phase angle in radians
//for star connection
vp=v/(3^0.5);//phase voltage in volts
xc=1/(2*%pi*f*c);//capacitive reactance in ohms
ic=vp/xc;//current in amperes
//ic leads the line voltage by 60degrees
cosP=cos((60*%pi)/180);//phase angle in radians
ii=(il*cos((phi*%pi)/180))+(ic*(cosP));//in-phase components in amperes
iq=((-il*sin((phi*%pi)/180))+(ic*sin(acos(cosP))));//quadrature component in amperes
it=((ii^2)+(iq^2))^0.5;//total current in amperes
PHI=(180/%pi)*acos(ii/it);//phase angle in degrees

//output
mprintf('the original line current was %3.0f A lagging on the line voltage by %3.0f degrees and
```

```
the final current is %3.1f A lagging on the line
voltage by %3.1f degrees',il,phi,it,PHI)
```

Scilab code Exa 8.8 determination of line and motor phase currents

```
clc
clear

//input
p=50;//power rating of a delta connected 3 phase a.c
   . motor in kW
v=415;//voltage rating of a delta connected 3 phase
   a.c. motor in volts
n=0.85;//full load effeciency in per units
pf=0.87;//full load power factor

//calculations
inp=p/n;//full load input in kW
il=inp*(1000/((3^0.5)*v*pf));//line current in
   amperes
ip=il/(3^0.5);//phase current in amperes

//output
mprintf('the line and motor phase currents are %3.0
   fA and %3.1fA respectively',il,ip)
```

Scilab code Exa 8.9 calculation of capacitance per phase

```
clc
clear

//input
```

```
p=27;//power rating of a delta connected 3 phase a.c
    . motor in kW
v=500;//voltage rating of a delta connected 3 phase
   a.c. motor in volts
n=0.9;//full load effeciency in per units
pf=0.7;//full load power factor
f=50;//general supply frequency in hertz

//calculations
il=(1000*p)/((3^0.5)*v*pf*n);//line current taken by
    motor in amperes
phi=acos(pf);//phase angle
//the line current will lag by phi radians on the
   line voltage
//to bring total current in phase with line voltage
   ic*sin60 must equal ilsin75.(information from
   phasor diagram)
ic=(il*sin(phi+0.524))/sin((60*%pi)/180);//capacitor
    current in amperes and 0.524 is 30degrees
   converted into radians and added in respect to
   above mentioned condition
c=(ic*1000000)/((3^0.5)*v*f*2*%pi);//capacitance per
    phase in micro farad

//output
mprintf('the required capacitance per phase is %3.0
   fuF',c)
```

Scilab code Exa 8.10 detrmining the wattmeter readings for given conditions

```
clc
clear

//input
```

```
v=415;// three phase supply voltage in volts
f=50;//supply frequency in hertz
//the power taken from this supply is taken by a delta connected load with each branch consisting a resistor and an inductance is measured by two wattmeters
r=20;//resistance in ohms
l=0.06;//inductance in henry

//calculations
xp=2*%pi*f*l;//reactance per phase in ohms
zp=((r^2)+(xp^2))^0.5;//impedance per phase in ohms
ip=v/zp;//current per phase in amperes
il=ip*(3^0.5);//line current in amperes
phi=acos(r/zp);//phase angle in radians
phi1=(30*%pi)/180;//30degrees converted into radians
w1=(v*il*cos(phi+phi1))/1000;//reading of wattmeter 1 and 30 degrees is added with correspondence to phasor diagram in kilowatts
w2=(v*il*cos(phi-phi1))/1000;//reading of wattmeter 2 and 30 degrees is added with correspondence to phasor diagram in kilowatts

mprintf('the readings on the two wattmeters will be %3.3f kW and %3.2f kW',w1,w2)
```

Chapter 9

the single phase transformer

Scilab code Exa 9.1 finding the number turns on secondary

```
clc
clear

//input
t1=96;//number turns on the primary side of an ideal
    transformer
v=240;//supply voltage in volts
f=50;//supply frequency in hertz
v2=660;//secondary pd in volts

//calculations
vp=v/t1;//primary volts per turn
vs=vp;//secondary volts per turn
t2=v2/vs;//secondary turns

//output
mprintf('to produce a p.d. of 660V the secondary
   coil should have %3.0f turns',t2)
```

Scilab code Exa 9.2 finding the secondary turns and the full load primary and secondary currents

```
clc
clear

//input
vp=660;//primary voltage in volts
vs=1100;//secondary voltage in volts
f=50;//supply frequency in hertz
kva=10;//kVA rating of the transformer
t1=550;//number of primary turns

//calculations
pv=vp/t1;//primary volts per turn
t2=vs/pv;//number of secondary turns
inpi=(kva*1000)/vp;//input current in amperes
is=(kva*1000)/vs;//secondary current in amperes

//output
mprintf('the number of secondary turns is %3.0f and
    the respective primary and secondary currents are
    %3.1fA and %3.1fA',t2,inpi,is)
```

Scilab code Exa 9.3 finding the mutual inductance between the windings

```
clc
clear

//input
t1=120;//primary turns of an ideal transformer
ls1=0.24;//self inductance of primary in henry
v=240;//supply voltage in volts
t2=300;//secondary turns of the ideal transformer

```

```
//calculations
d=v/ls1;//rate of change of current in A/s
v2=v*(t2/t1);//secondary voltage in volts
M=v2/d;//mutual impedance in henry
ls2=ls1*((t2*t2)/(t1*t1));//self inuctance of the
    secondary in henry

//output
mprintf('the mutual impedance between the coils is
    %3.1fH and the self inductance of the secondary
    winding is %3.1fH',M,ls2)
```

Scilab code Exa 9.4 finding magnetizing current and the no load loss

```
clc
clear

//input
i=0.4;//no load current in amperes
pf=0.25;//lagging power factor
v=250;//supply voltage in volts
f=50;//supply frequency in hertz

//calculations
ie=i*pf;//loss component of no load current in
    amperes
im=((i^2)-(ie^2))^0.5;//magnetizing component in
    amperes
p=v*ie;//no load power loss in watts

//output
mprintf('the magnetising current is %3.3fA and the
    no load loss is %3.0f W',im,p)
```

Scilab code Exa 9.5 finding the flux density in the core

```
clc
clear

//input
v=240;//supply voltage in volts
f=50;//supply frequency in hertz
t1=500;//number of primary turns
i0=0.35;//no load current in amperes
p=44;//power loss in watts
l=0.4;//magnetic length of the core in meters
ur=2000;//relative permeability of core
u0=1.257*(10^-6);//absolute permeability

//calculations
cosp=p/(v*i0);//no load power factor
im=i0*sin(acos(cosp));//magnetizing current in
    amperes
b=(u0*ur*im*t1)/l;//flux density in tesla

//output
mprintf('the flux density produced in the core will
    be %3.3f T',b)
```

Scilab code Exa 9.6 determination of components of parallel circuit

```
clc
clear

//input
vp=440;//primary voltage in volts
```

```
vs=240;//secondary voltage in volts
f=50;//supply voltage in hertz
i0=0.5;//no load current in amperes
pf=0.3;//lagging power factor

//calculations
ii=i0*pf;//in phase component in amperes
r0=vp/(ii*1000);//resistance in ohms
iq=((i0^2)-(ii^2))^0.5;//quadrature component in amperes
x0=vp/iq;//reactance in ohms
l0=x0/(2*%pi*f);//inductance in henry

//output
mprintf('the transformer on load may be represented by %3.2fkOhms resistance in parallel with a pure inductance of %3.2fH',r0,l0)
```

Scilab code Exa 9.7 finding number of primary and secondary turns

```
clc
clear

//input
vp=1100;//voltage on the primary in volts
vs=240;//secondary voltage in volts
f=50;//supply frequency in hertz
b=1.4;//flux density in tesla
s=0.2;//side of the square core in meter

//calculations
ag=s*s;//gross area of core in square meters
am=0.9*ag;//magnetic area of core in square meters
np=vp/(4.44*b*am*f);//number of turns in primary
ns=np*(vs/vp);//number of turns in secondary
```

```
//output
mprintf('the number of turns in the primary and
   secondary winding would be %3.0f and %3.0f
   respectively',np,ns)
```

Scilab code Exa 9.8 estimation of flux density magnetizing current and core loss

```
clc
clear

//input
np=350;//number of turn in the primary
lm=0.8;//mean length of core in meters
am=0.006;//magnetic area in square meter
i0=0.8;//no load current in amperes
v=500;//supply voltage in volts
f=50;//frequency of supply in hertz
ur=2000;//relative permeability of the core
u0=1.257*(10^-6);//absolute permeability

//calculations
bm=v/(4.44*am*np*f);//maximum flux density in tesla
im=(bm*i0)/(u0*ur*np*(2^0.5));//magnetizing current
   in amperes
sinp=im/i0;//sine of no load phase angle
p=v*lm*cos(asin(im/i0));//power loss of core in
   watts

//output
mprintf('the maximum flux density in the core will
   be %3.3fT with a magnetizing current of %3.3fA
   and a core loss of %3.0fW',bm,im,p)
```

Scilab code Exa 9.9 calculation of different efficiencies and loading for maximum efficiency

```
clc
clear

//input
kva=20000;//kVA rating of the transformer in VA
vp=1100;//primary voltage in volts
vs=240;//secondary voltage in volts
pi=500;//iron losses in watts
pc=600;//full load copper losses in watts
pf=0.8;//lagging power factor

//calculations
out=kva*pf;//full load output in watts
fll=pi+pc;//full load losses in watts
n=out/(out+fll);//efficiency in perunits
hfl=kva/2;//unity power factor
cp=pc*(1/(2*2));//copper loss in watts
n1=(hfl/1000)/((hfl/1000)+0.5+(cp/1000));//
   efficiency in per units
kvat=(kva*((pi/pc)^0.5))/1000;// total kVA

//output
mprintf('the efficiencies on full load,at 0.8 lag
   and 0.5*full load,at unity power factor are %3.3f
    p.u. and %3.2f p.u. respectively.\n the loading
   for maximum efficiency is %3.2f kVA',n,n1,kvat)
```

Scilab code Exa 9.10 calculation of all day efficiency

```
clc
clear

//input
kva=10;//kVA rating of the transformer
vp=400;//voltage on primary side in volts
vs=230;//voltage on secondary side in volts
//short circuit test
ppd1=18;//primary p.d. in volts
ip1=25;//primary current in amperes
inp1=120;//power input in watts
//short circuit test
ppd2=400;//primary p.d. in volts
ip2=0.5;//primary current in amperes
inp2=70;//power input in watts

//calculations
zp=ppd1/ip1;//equivalent primary impedance in ohms
rp=inp1/(ip1^2);//equivalent resistance in ohms
xp=((zp^2)-(rp^2))^0.5;//equivalent leakage
    reactance in ohms
r0=(vp^2)/(1000*inp2);//resistance of parallel
    circuit
phi=sin(acos(inp2/(vp*ip2)));//sine of power factor
im=ip2*phi;//magnetizing current in amperes
x0=vp/im;//reactance in ohms

//output
mprintf('the equivalent circuit parameters are \n Rp
    =%3.3f ohms \n Xp=%3.3f ohms \n r0=%3.3f kilo
    ohms \n x0=%3.1f ohms',rp,xp,r0,x0)
```

Scilab code Exa 9.11 determination of equivalent circuit

```
clc
```

```
clear

//input
kva=10;//kVA rating of the transformer
vp=400;//voltage on primary side in volts
vs=230;//voltage on secondary side in volts
//short circuit test
ppd1=18;//primary p.d. in volts
ip1=25;//primary current in amperes
inp1=120;//power input in watts
//short circuit test
ppd2=400;//primary p.d. in volts
ip2=0.5;//primary current in amperes
inp2=70;//power input in watts

//calculations
zp=ppd1/ip1;//equivalent primary impedance in ohms
rp=inp1/(ip1^2);//equivalent resistance in ohms
xp=((zp^2)-(rp^2))^0.5;//equivalent leakage
    reactance in ohms
r0=(vp^2)/(1000*inp2);//resistance of parallel
    circuit
phi=sin(acos(inp2/(vp*ip2)));//sine of power factor
im=ip2*phi;//magnetizing current in amperes
x0=vp/im;//reactance in ohms

//output
mprintf('the equivalent circuit parameters are \n Rp
    =%3.3f ohms \n Xp=%3.3f ohms \n r0=%3.3f kilo
    ohms \n x0=%3.1f ohms',rp,xp,r0,x0)
```

Scilab code Exa 9.12 finding the primary input current secondary terminal voltage and the efficiency

```
clc
```

```
clear

//input
kva=5;//kVA rating of the transformer
pf=0.8;//power factor
vp=250;//voltage on primary side in volts
vs=500;//voltage on secondary side in volts
//from equivalent circuit
r0=750;//resistance in ohms
x0=325;//reactance in ohms
Rp=0.4;//equivalent resistance refered to primary side in ohms
Xp=0.75;//equivalent reactance refered to primary side in ohms

//calculations
is=(kva*1000)/vs;//full load secondary current in amperes
ip1=is*(vs/vp);//current in amperes
ep=vp-((ip1*pf)+(Xp*sin(acos(pf))));//in volts
Vs=ep*(vs/vp);// in volts
i1=vp/(vs+vp);//component of Io in phase with Vs in amperes
i2=i1*pf;//component of Ie in phase with Ip
i3=i1*sin(acos(pf));//component of Ie in quadrature with Ip
im=vp/x0;//magnetizing current in amperes
i4=im*sin(acos(pf));//component of Im in phase with Ip
i5=im*pf;//component of Im in quadrature with Ip
Ip=(((ip1+i2+i4)^2)+((i5-i3)^2))^0.5;//total primary current in amperes
P=vp*Ip*pf;//power input in watts
pc=ip1*ip1*i4;//copper loss in watts
pi=vp*i1;//iron loss in watts
n=1-((pc+pi)/P);//efficiency in per units

//output
```

```
mprintf('the primary input current is %3.2f A : the
   secondary terminal voltage is %3.0f V and the
   efficiency of the transformer is %3.2f p.u.',Ip,
   Vs,n)
```

Scilab code Exa 9.13 calculation of secondary terminal voltage

```
clc
clear

//input
//all values refered to primary and from given
   equivalent circuit
v=240;//supply voltage in volts
r0=0.25;//resistance in ohms
x0=0.4;//reactance in ohms
rl=7.75;//load resistance in ohms
xl=5.6;//load reactance in ohms
n=5;//turns ratio of the transformer

//calculations
rt=r0+rl;//total resistance of the circuit in ohms
xt=x0+xl;//total reactance of the circuit in ohms
zt=((rt^2)+(xt^2))^0.5;//total impedance of
   transformer and the load in ohms
Ip=v/zt;//current in amperes
zl=((rl^2)+(xl^2))^0.5;//impedance of load in ohms
d=Ip*zl;//voltage drop across referred load
   impedance in volts
vs=n*d;//secondary terminal voltage in volts

//output
mprintf('the secondary terminal voltage is %3.0f V',
   vs)
```

Chapter 10

synchronous and asynchronous machines

Scilab code Exa 10.1 determination of emf between ends of a coil

```
clc
clear

//input
p=4;//number of poles of an alternator
w=50*%pi;//angular velocity in rad/sec
b=0.015;//sinusoidal flux per pole in weber
phi=10*(%pi/180);//pole pitch in radians
kf=1.11;//form factor

//calculations
f=(w*(p/2))/(2*%pi);//frequency in hertz
e=2*kf*b*f;//e.m.f. per conductor in volts
E=2*e*cos(phi/2);//total e.m.f. in volts

//ouput
mprintf('the e.m.f. between the ends of the coil is
   %3.1f V',E)
```

Scilab code Exa 10.2 finding the emf between the ends of the series connected coils

```
clc
clear

//input
p=4;//number of poles
n=48;//number of slots
b=0.02;//fulx per pole in weber
w=50*(%pi);//angular velocity in rad/sec

//calcultions
f=(w*(p/2))/(2*%pi);//frequency in hertz
phim=360/n;//mechanical angle in degrees
phie=phim*(p/2);//electrical angle in degrees
phiE=phie*(%pi/180);//electrical angle in radians
kd=(sin(2*(phiE/2)))/(2*sin(phiE/2));//distribution
    factor and 2 is taken as we are calculating for 2
     coils
e=(p/2)*kd*4.44;//total e.m.f. for two coils in
    series in volts

//output
mprintf('the total e.m.f. for two coils in series is
     %3.1f V',e)
```

Scilab code Exa 10.3 calculation of phase and line voltages

```
clc
clear

```

```
//input
p=6;//number of poles
n=72;//number of slots
n1=10;//conductors per slot
b=0.01;//flux per pole in weber
f=50;//frequency in hertz
phi=170;//pitch of coil in electrical degrees
kf=1.11;//form factor for sinusoidal forms

//calcultions
n2=n/p;//number of slots per pole
n3=n2/3;//number of slots per pole per phase for 3
    phase system
phim=360/n;//mechanical angle between slots in
    degrees
phie=phim*(p/2);//electrical angle in degrees
phiE=phie*(%pi/180);//electrical angle in radians
kd=(sin(n3*(phiE/2)))/(n3*sin(phiE/2));//
    distribution factor
phis=(180-phi)*(%pi/180);//coil spam factor in
    radians
kc=cos(phis);//pitch factor in radians
e=2*kd*kc*kf*f*b*((n*n1)/3);//e.m.f. per phase in
    volts
vl=(3^0.5)*e;//line voltage for star connection in
    volts

//output
mprintf('the phase and line voltages are %3.0f V and
     %3.0f V respectively',e,vl)
```

Scilab code Exa 10.4 calculation of torque produced

```
clc
clear
```

```

//input
p=4;//number of poles
n1=3;//number of phases
f=50;//frequency in hertz
inp=60;//input to the motor in kW
l=0.06;//losses in per units

//calculations
w=2*%pi*(f/(p/2));//angular velocity in rad/sec
t=(inp*1000)/w;//total torque produced in newton
    meter
tu=t-(t*l);//useful torque in newton meter

//calculations
mprintf('the total torque and the useful torque of
    the machine are %3.0f Nm and %3.0f Nm
    respectively',t,tu)
```

Scilab code Exa 10.5 determination torque produced

```
clc
clear

//input
p=2;//number of poles
v=415;//3 phase supply voltage in volts
n=3;//number of phases
x=0.6;//reactance of phase in ohms
f=50;//supply ferquency in hertz
e=0.08;//resultant e.m.f. is 0.08 of supply voltage

//calculations
e1=(e*v)/(3^0.5);//resultant e.m.f. per phase in
    volts
```

```
i=e1/x;//current per phase in current
il=i;//line current in amperes
phi=(180/%pi)*atan(e);//load angle in degrees
the=(180-phi)/p;
PHI=cos(atan(e));//power factor
inp=(3^0.5)*v*PHI*il;//power input in watts
t=inp/(2*%pi*(f/(p/2)));//torque in newton meter

//output
mprintf('the total torque produced is %3.0f Nm',t)
```

Scilab code Exa 10.6 finding the slip speed and the slip

```
clc
clear

//input
n=3;//number of phases
f=50;//frequency in hertz
w=96*(%pi);//angular velocity in rad/sec

//calculations
ws=(2*%pi*f)-w;//slip speed in rad/sec
s=ws/(2*%pi*f);//slip in per units

//output
mprintf('the slip speed is %3.2f rad/s and the slip
   is %3.2f p.u.',ws,s)
```

Scilab code Exa 10.7 finding the rotor speed and the frequency of rotor components

```
clc
```

```
clear

//input
p=6;//number of poles
n=3;//number of phases
f=50;//frequency in hertz
s=0.03;//slip in per units

//calculations
w=(2*%pi*f*60)/(n*2*%pi);//synchronous speed in rev/
    min
ws=s*w;//slip speed in rev/min
wr=w-ws;//rotor speed in rev/min
fs=(ws*n)/60;//frequency of rotor currents in
    amperes

//output
mprintf('the rotor speed will be %3.0f rev/min and
    the frequency of rotor currents will be%3.1f Hz',
    wr,fs)
```

Scilab code Exa 10.8 calculation of slip rotor copper loss total torque and the efficiency

```
clc
clear

//input
p=4;//number of poles
f=50;//supply frequency in hertz
n=3;//number of phases
w=1440;//speed in rev/min
sl=1.5;//stator losses in kW
fl=1.2;//friction losses in kW
inp=60;//input to motor in kW
```

```
//calculations
N=(inp*f)/(p/2);//synchronous speed in rev/min
ns=N-w;//slip speed in rev/min
s=ns/N;//slip in per units
rinp=inp-sl;//rotor input in kW
rc=s*rinp;//rotor copper losses in kW
tr=(rinp*1000)/((N*2*%pi)/60);//rotor torque in newton meter
rout=rinp-rc;//rotor output in kW
mout=rout-fl;//motor output in kW
eff=mout/inp;//efficiency of rotor in per unit

//output
mprintf('the slip is %3.2f p.u.:the rotor copper loss is %3.2f kW: the total torque is %3.0f Nm and the efficiency is %3.3f p.u.',s,rc,tr,eff)
```

Scilab code Exa 10.9 calculation of rotor copper loss and the input and efficiency of the motor

```
clc
clear

//input
p=6;//number of poles
f=50;//frequency in hertz
n=3;//number of phases
t=160;//total torque in newton meter
fs=120;//slip frequency in cycles/min
tf=12;//torque lost in friction
sl=750;//stator losses in watts

//calculations
s=fs/(60*f);//slip in per unit
```

```
w=(2*%pi*f)/n;//speed of motor in rad/sec
wr=w*(1-s);//rotor speed in rad/sec
rinp=t*w;//rotor input in watts
rc=s*rinp;//rotor copper losses in watts
sinp=rinp+sl;//stator input in watts
Sinp=sinp/1000;//stator input in kilowatts
tout=t-tf;//output torque in newton meter
pout=tout*wr;//power output in watts
eff=pout/sinp;//efficiency in per unit

//output
mprintf('the rotor loss is %3.0fW, the input to the motor is %3.2f kW and the motor efficiency is %3.2f p.u.',rc,Sinp,eff)
```

Chapter 11

electronics

Scilab code Exa 11.1 determination of anode slope resistance the mutual conductance and the amplification factor

```
clc
clear

//input
va=120;//annode voltage in volts
vg1=-1;//grid voltage in volts
vg2=-2;//grid voltage for which another curve is
   drawn in volts
//given scale is vertical scale: anode current 1mm
   =0.00025A and horizontal scale : anode voltage 1
   mm=2.5V
//from VI characteristics
i=0.00025;//current in amperes
v=2.5;//voltage in volts
CD=4;
BD=9;
EF=34;
CE=14.5;
//calculations
ra=(CD*v)/(BD*i*1000);//anode slope resistance in
```

```
kilo ohms
gm=(EF*i*1000)/(vg1-vg2);//mutual conductance in millisiemens
u=(CE*v)/(vg1-vg2);//amplification factor

//ouput
mprintf('at the operational point the parameters of the valve are %3.2f kohms,%3.1f mS and %3.2f.',ra,gm,u)
```

Scilab code Exa 11.2 determination of the triode parameters

```
clc
clear

//input
va1=125;//anode voltage in volts
va2=100;//anode voltage in volts for which another curve is obtained
vg1=0;//grid voltage in volts
vg2=-1;//grid voltage in volts
//given scale is vertical scale: anode current 1mm=0.0002A and horizontal scale : anode voltage 1mm=0.1V
v=0.1;//voltage in volts from scale
//from given data
//for vg1 and va2
ia11=4.8;//current in milli amperes
ia12=3.2;//current in milli amperes
//for vg2 and va1
ia21=6.625;//current in amperes
ia22=5.0;//current in amperes

//calculations
ra=(va1-va2)/(ia21-ia11);//anode slope resistance in
```

```
    kilo ohms
gm=(ia21-ia22)/(vg1-vg2);//mutual conductance in
    millisiemens
u=(va1-va2)/(v-vg2);//amplification factor

//ouput
mprintf('at the operational point the parameters of
    the valve are %3.1f kohms,%3.3f mS and %3.1f.',ra
    ,gm,u)
```

Scilab code Exa 11.3 finding the required anode voltage

```
clc
clear

//input
ia=0.002;//anode current in amperes
rl=5000;//resistance in ohms
vht=100;//anode voltage in volts

//calculations
va=vht-(ia*rl);//next anode voltage in volts to plot
    the characteistic curve

//output
mprintf('the next required anode voltage for
    plotting characteristic curve is %3.0fV',va)
```

Scilab code Exa 11.4 determination of operating points

```
clc
clear

```

```
//input
vht=100;//higher threshold voltage in volts
rl1=5;//resistance of load in kiloohms
rl2=10;//load resistance in kiloohms

//calculations
//for rl1
//when va=0
ia1=vht/rl1;//anode current in milliamperes
//when va=100
ia2=0;//since va=vht
//for rl2
//when va=0
ia3=vht/rl2;//anode current in milliamperes
//when va=100
ia4=0;//since va=vht
//two load lines are drawn on VI graph which coincides the aanode characteristic curve at four points
//using the data given
//point 1
vg1=0;//grid voltage in volts
va1=71;//anode voltage in volts
i1=5.9;//anode current in milliamperes
//point 2
vg2=-2;//grid voltage in volts
va2=79;//anode voltage in volts
i2=4.3;//anode current in milliamperes
//point 3
vg3=0;//grid voltage in volts
va3=57;//anode voltage in volts
i3=4.3;//anode current in amperes
//point 4
vg4=-2;//grid voltage in volts
va4=68;//anode voltage in volts
i4=3.2;//anode current in amperes

//output
```

```
mprintf('for a load of 5kiloohm,the operating points are \n vg=%3.0fV: va=%3.0fV ia=%3.1fmA \n vg=%3.0fV: va=%3.0fV ia=%3.1fmA \n for a load of 10 kiloohms,the operating points are \n vg=%3.0fV: va=%3.0fV ia=%3.1fmA \n vg=%3.0fV: va=%3.0fV ia=%3.1fmA',vg1,va1,i1,vg2,va2,i2,vg3,va3,i3,vg4,va4,i4)
```

Scilab code Exa 11.5 finding the voltage amplification

```
clc
clear

//input
g=4;//mutual conductance of a triode in millisiemens
u=25;//amplification factor
l=20;//load in kilo ohms

//calculations
ra=u/g;//slope resistance in kilo ohms
av=(u*l)/(ra+l);//voltage gain

//output
mprintf('with aload resistance of 20 kilo ohms this triode will give a voltage amplification of %3.2f',av)
```

Scilab code Exa 11.6 determination of ac voltage across the load

```
clc
clear

//input
```

```
rc=50;//resistance of the coil in ohms
lc=0.0005;//inductance of the coil in henry
//coil is connected in parallel with a capcitor
fr=0.5*(10^6);//resonance frequency in hertz
vl=1.5;//voltage across the load in volts
rs=50000;//slope resistance in ohms of the triode
u=25;//amplification factor of the triode

//calculations
c=(lc*(10^12))/((rc^2)+(2*%pi*fr*lc)^2);//
    capacitance in picofarad
rl=(lc*(10^9))/(rc*c);//resistance of load in
    kiloohms
a=(u*rl)/(rc+rl);//voltage amlification
e0=a*vl;//a.c. voltage across load in volts

//output
mprintf('at a frequency of 0.5MHz the a.c. voltage
    across the load will be %3.1fV in antiphase to
    the 1.5V in the grid circuit',e0)
```

Scilab code Exa 11.7 calculation of input resistances

```
clc
clear

//input
ib1=-50;//base current in micro amperes
vce1=0;//emitter collector voltage in volts
ib2=-25;//base current in microamperes
vce2=6;//emitter collector voltage in volts
//locate a point at vce=0V and Ib=-50uA and draw
    tangent to it.
//from tangent co-ordinates
a1=150;
```

```
a2=87.5;
a3=75;
a4=25;
//locate a point at vce=6V and Ib=-25uA and draw a
   tangent to it.
//from the tangent co-ordinates
vbe1=200;//base emitter voltage in millivolts
vbe2=100;//base emitter voltage in millivolts
vbe3=50;//base emitter voltage in millivolts
vbe4=0;//base emitter voltage in millivolts

//calculations
ri=((a1-a2))/(a3-a4);//input resistance in kilo ohms
Ri=(vbe1-vbe2)/(vbe3-vbe4);//input resistance in
   kilo ohms

//output
mprintf('the input resistances for the specified
   conditions are %3.2f kilo ohms and %3.0f kilo
   ohms.',ri,Ri)
```

Scilab code Exa 11.8 determination of output resistances

```
clc
clear

//input
ib1=-100;//base current in micro amperes
vce1=10;//emitter collector voltage in volts
ib2=-50;//base current in microamperes
vce2=25;//emitter collector voltage in volts
//locate a point at vce=10V and Ib=-100uA and draw
   tangent to it.
//from tangent co-ordinates
a1=20;
```

```
a2=5;
a3=5.22;
a4=4.55;
//locate a point at vce=25V and Ib=-50uA and draw a tangent to it.
//from the tangent co-ordinates
vbe1=30;//base emitter voltage in millivolts
vbe2=20;//base emitter voltage in millivolts
vbe3=3.65;//base emitter voltage in millivolts
vbe4=2.9;//base emitter voltage in millivolts

//calculations
r0=((a1-a2))/(a3-a4);//input resistance in kilo ohms
R0=(vbe1-vbe2)/(vbe3-vbe4);//input resistance in kilo ohms

//output
mprintf('the output resistances for the specified conditions are %3.1f kilo ohms and %3.1f kilo ohms.',r0,R0)
```

Scilab code Exa 11.9 finding the parameters of the operating points

```
clc
clear

//input
ib=-10;//base current in microamperes
rl=6;//load resistance in kilo ohms
v=30;//supply voltage in volts

//calculations
//when vce=0V
ic=v/rl;//collector current in milliamperes
//whenic=0mA
```

```
vce=v;//collector emitter voltage in volts
//line AB where A(Vce=0V,Ic=5mA) and B(Vce=30V,Ic=0 mA) cuts characteristic curve at point P
//from co-ordinates of P
Vce=16;//collector emitter voltage in volts
Ic=2.4;//collector current in milliamperes
ie=Ic+(-ib/1000);//emitter current in amperes

//output
mprintf('the parameters of the operating point under the conditions specified are Vce=%3.0fV,Ic=%3.1fmA and Ie=%3.2fmA',Vce,Ic,ie)
```

Scilab code Exa 11.10 calculation of current gain

```
clc
clear

//input
rl=10;//load resistance in kiloohms
//for Ie= 0 ,0.8,2.0,2.8,4.0 Ic=0,0.78,1.95,2.73,3.9 respectively in mA
//taking any two set of values
ic1=3.9;
ic2=0;
ie1=4;
ie2=0;

//calculations
cg=(ic1-ic2)/(ie1-ie2);//current gain

//output
mprintf('the current gain is %3.3f',cg)
```

Scilab code Exa 11.11 determination of collector emitter voltage and current gain

```
clc
clear

//input
//from the characteristics when Vce=15V
ic1=5;//collector current in milli amperes
ic2=2.8;//collector current in milli amperes
ib1=100;//base current in micro amperes
ib2=50;//base current in micro amperes

//calculations
b=((ic1-ic2)*1000)/(ib1-ib2);//current gain

//output
mprintf('when the collector-emitter voltage is 15V
   the current gain is %3.0f',b)
```

Scilab code Exa 11.12 calculation of voltage and current gains

```
clc
clear

//input
rl=2.5;//resistance of load in kilo ohms
//from VI charecteristic curves
//for bias current of -10uA
vce1=21;//in volts
ic1=3.6;//in mA
ib1=-10;//in uA
```

```
//for bias current of -15uA
vce2=14.75;//in volts
ic2=6;//in mA
ib2=-15;//in uA
//from input characteristic curve
vbe1=0.75;
vbe2=0.45;
Ib1=40;
Ib2=0;

//calculations
b=((-ic2-(-ic1))*1000)/(ib2-ib1);//current gain
s=(vbe1-vbe2)/(Ib1-Ib2);//slope of curve
S=s*5;//for change in 5mV
v=(vce1-vce2)/S;

//output
mprintf('the voltage and current gains are %3.0f and
    %3.0f',v,b)
```

Scilab code Exa 11.13 calculation of voltage gain

```
clc
clear

//input
b=50;//current gain
rl=10;//load resistance in kilo ohms
rint=6.5;//internal resistance of an alternating
    source in kilo ohms
rinp=1;//input resistance in kiloohms

//calculations
v=(rl*b)/(rint+rinp);//voltage gain

```

```
//output
mprintf('the voltage gain under given conditions will be %3.0f',v)
```

Scilab code Exa 11.14 finding voltage gain when h parameters are given

```
clc
clear

//input
//given h-parameters of a junction transistor
hie=1000;//in ohms
hoe=100*(10^-6);//Sec
hre=0.0005;
hfe=50;
rl=10000;//load resistance in ohms

//calculations
Yt=hoe+(1/rl);
v=(1/((hie*(-Yt/hfe))+hre));//voltage gain and - signifies the 180 degree phase shift
vg=-v;
//output
mprintf('the voltage gain would be %3.0f',vg)
```

Scilab code Exa 11.15 calculation of required load resistance

```
clc
clear

//input
//given h-parameters of a junction transistor
hie=1000;//in ohms
```

```
hoe=100*(10^-6);//Sec
hre=0.0005;
hfe=50;
cg=30;//current gain

//calculations
yl=(cg*hoe)/(hfe-cg);//load admittance in kilo mho
rl=1/(yl*1000);//load resistance in kilo ohms

//output
mprintf('to give a current gain of 30 the load would
    have to have a resistance of %3.2f kilo ohms',rl
   )
```