Scilab Textbook Companion for Electrical And Electronic Engineering by U. A. Bakshi And V. U. Bakshi[1]

Created by
Prakhar Bangar
B.Tech
Electrical Engineering
Manipal Unviversity
College Teacher
No Teacher
Cross-Checked by
Ganesh R

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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

Electrical Circuits

Scilab code Exa 1.1 obtain the waveform

```
//example1.1
clc
disp("From the give waveform,")
s=100/2
disp(s,"For 0<t<2, i(t) is a straight line slope=")
disp("Therefore   i(t)=50t and di(t)/dt=50  .. 0<t<2")
disp("For 2<t<4,   i(t)=100 and di(t)/dt=0")
s=(-100)/2
disp(s,"For 4<t<6, i(t) is a straight line slope = ")
disp("Therefore,   i(t)= -50t and di(t)/dt= -50 ..4<t<6")
disp("Now   v_l(t)=L*di(t)/dt")
v=(50)*10^-3
format(5)
disp(v,"V_l(t)[in volts   from 0<t<2]=")
v=0*10^-3
disp(v,"V_l(t)[in volts   from 2<t<4]=")
v=(-50)*10^-3
disp(v,"V_l(t)[in volts   from 4<t<6]=")
```

```
disp("The waveform is shown in the fig. 1.12(a)")
```

Scilab code Exa 1.2 find equivalent resistance

```
//example1.2
clc
disp("Identify combinations of series and parallel
    resistances.")
disp("The resistances 5ohm and 6ohm are in series,
    as going to carry same current.")
r=5+6
disp(r,"So equivalent resistance is(in ohm)=")
disp("While the resistances 3ohm,4ohm,4ohm are in
    parallel, as voltage across them same but current
     divides.")
r=10/12
format(4)
disp(r,"(1/R)=(1/3)+(1/4)+(1/5)=")
r=12/10
disp(r,"Therefore,  R(in ohm)=")
disp("Replacing these combinations redraw the fig.
    as shown in the fig. 1.28(a)")
disp("Now again 1.2ohm and 2ohm are in series so
    equivalent resistance is 2+1.2=3.2 ohm while 11
    ohm and 7ohm are in parallel.")
disp("Using formula (R1*R2)/(R1+R2)")
r=77/18
format(6)
disp(r,"equivalent resistance3 is (11*7)/(11+7)[in
    ohm]=")
disp("Replacing the respective combination redraw
    the circuit as shown in the fig 1.28(b).")
disp("Now 3.2 and 4.277 are in parallel")
r=(3.2*4.277)/(3.2+4.277)
format(7)
```

```
disp(r,"Therefore , replacing them by (3.2*4.277)/(3.2+4.277)[in ohm]=")
r=1+1.8304
disp(r,"R_ab(in ohm)=")
```

Scilab code Exa 1.3 voltage across three resistances

```
//example1.3
clc
disp("I=v/(R1+R2+R3)  .....  series circuit")
i=60/60
disp(i,"I(in amp)=")
v=1*10
disp(v,"Therefore ,  V_r1(in V)=(I*R1)=(V*R1)/(R1+R2+R3)=")
v=1*20
disp(v,"Therefore ,  V_r2(in V)=(I*R2)=(V*R2)/(R1+R2+R3)=")
v=1*30
disp(v,"and ,  V_r3(in V)=(I*R3)=(V*R3)/(R1+R2+R3)=")
disp("Key point: It can be seen that voltage across any resistance of series circuit is ratio of that resistance to the total resistance , multiplied by the source voltage.")
```

Scilab code Exa 1.4 magnitudes of total current

```
//example1.4
clc
disp("The equivalent resistance of two is ,")
r=(10*20)/30
format(5)
disp(r,"R_eq(in ohm)=(R1*R2)/(R1+R2)=")
```

```
i=50/6.67
format(4)
disp(i,"I_t(in amp)=V/R_eq=")
disp("As per the current distribution in parallel
    circuit,")
i=(7.5*20)/30
disp("I_1(in amp)=(I_t*R2)/(R1+R2)=")
i=75/30
disp(i,"and,  I_2(in amp)=(I_t*R1)/(R1+R2)=")
disp("It can be verified that I_t=(I1)+(I2).")
```

Scilab code Exa 1.5 find the values of currents

```
//example1.5
clc
disp("Application of Kirchhoffs law:")
disp("Step 1 and 2: Draw the circuit with all values
     which are same as the given network. Mark all
    the branch starting from +ve of any of the source
    , say +ve of 50V source.")
disp("Step 3: Mark all the polarities for different
    voltages across the resistances. This is combined
     with step2 shown in the network below in fig
    1.41(a).")
disp("Step 4: Apply KVL to different loops.")
disp("Loop 1: A-B-E-F-A , -15(I_1)-20(I_2)+50=0")
disp("Loop 2: B-C-D-E-B , -30((I_1)-(I_2))-100+20(
    I_2)=0")
disp("Rewriting all the equations,taking constants
    in one side.")
disp("15(I_1)+20(I_2)=50  ..(1)")
disp("-30(I_1)+50(I_2)=100  ..(2)")
disp("Apply cramers rule,")
d=(15*50)-(-30*20)
format(5)
```

```
disp(d,"D=[15 20;-30 50]=")
disp("Calculating D_v")
d=(50*50)-2000
disp(d,"D1=[50 20;100 50]=")
i=500/1350
disp(i,"I_1(in amp)=(D_1)/D=")
disp("Calculating D2 ,")
d=1500+(30*50)
disp(d,"D2=[15 50;-30 100]=")
i=3000/1350
disp(i,"I_2(in amp)=D2/D=")
disp("For I_1 and I_2, as answer is positive, assumed direction is correct")
disp("Therefore, for I_1 answer is 0.37 amp. For I_2 answer is 2.22amp")
i=0.37-2.22
format(5)
disp(i,"(I_1)-(I_2)[in amp]=")
disp("Negative sign indicates assumed direction is wrong.")
disp("i.e (I_1)-(I_2)=1.85A flowing in opposite direction to that of the assumed direction.")
```

Scilab code Exa 1.6 find i1 and i2

```
//example1.6
clc
disp("The current distribution using KCL is as shown,")
disp("Key Point : KVL should not be applied to the loop consisting current source.")
disp("From branch DE,")
disp("(i1)=5+3(i2)   ...(1)")
disp("Applying KVL to the loop BCDEFGB without current source,")
```

```
disp("-1*(5+3(i2))+5(i2)=0        ...(2)")
disp("2(i2)=5")
i=5/2
disp(i,"i2(in amp)=")
disp("from eq.(1)")
i=5+(3*2.5)
disp(i,"i1(in amp)=")
```

Scilab code Exa 1.7 transform voltage source to current source

```
//example1.7
clc
disp("Refer to the fig 1.45(a).")
i=20/5
disp(i,"Then current of current source is, I(in A)=V/R_sc=")
disp("with internal parallel resistance same as R_sc")
disp("Therefore , Equivalent current is as shown in the fig. 1.45(b).")
```

Scilab code Exa 1.8 convert current source to voltage source

```
//example
clc
disp("The given values are, I=50A and R_sh= 10ohm")
disp("For the equivalent voltage source,")
v=10*50
disp(v,"V(in V)=(I*R_sh)=")
disp("R_se=R_sh=10ohm in series.")
disp("The equivalent voltage source is shown in the fig 1.46(a)")
```

```
disp("Note the polarities of voltage source, which
    are such that +ve at top of arrow and −ve at
    botttom.")
```

Scilab code Exa 1.9 convert delta to star

```
//example1.9
clc
disp("Its equivalent star is as shown in the fig
    1.57. where,")
r=50/30
format(5)
disp(r,"R1(in ohm)=(10*50)/(5+10+15)=")
r=150/30
disp(r,"R2(in ohm)=(15*10)/(5+10+15)=")
r=75/(30)
disp(r,"R3(in ohm)=(15*5)/(5+10+15)")
```

Scilab code Exa 1.10 find equivalent resistance

```
//example1.10
clc
disp("Redrawing the circuit,")
r=(21*14)/(21+14)
format(4)
disp(r,"R_ab(in ohm)=(21*14)/(21+14)=")
```

Scilab code Exa 1.11 find equivalent resistance

```
//example1.11
```

```
clc
disp("Redrawing the circuit,")
disp("R1 and R2 are in series from fig. 1.59(b)")
r=150/25
disp(r,"R1(in ohm)=(15*10)/(15+10)=")
r=24/10
disp(r,"R2(in ohm)=(6*4)/(6+4)=")
disp("then, R_ab=R1+R2")
r=6+2.4
disp(r,"Therefore, R_ab(in ohm)=6+2.4=")
```

Scilab code Exa 1.12 find current

```
//example1.12
clc
disp("The various loop are shown in the fig 1.64(a)"
   )
disp("Apply KVL to the various loops,")
disp("Loop 1,  -15(I_1)-20(I_1)+20(I_2)+100=0")
disp("Therefore,  +35(I_1)-20(I_2)=100   ...(1)")
disp("Loop 2,  -5(I_2)-30(I_2)+30(I_3)-20(I_2)+20(
   I_1)=0")
disp("Therefore,  20(I_1)-55(I_2)+30(I_3)=0   ...(2)
   ")
disp("Loop 3,  -5(I_3)-100-30(I_3)+30(I_2)=0")
disp("Therefore,  30(I_2)-35(I_3)=0   ...(3)")
d=35*((55*35)-(30*30))+20*(-35*20)
format(6)
disp(d,"D1=[35 -20 0;20 -55 30;0 30 -35]=")
d=35*(-(100*30))-100*(-35*20)
disp(d,"D2=[35 100 0;20 0 30;0 100 -35]=")
d=35*(-55*100)-(-20*(20*100))+100*(30*20)
disp(d,"D3=[35 -20 100;20 -55 0;0 30 100]=")
i=(-35000)/21875
format(4)
```

```
disp(i,"I_2(in amp)=D2/D=")
i=(-92500)/21875
format(7)
disp(i,"I_3(in amp)=D3/D=")
i=(-1.6)+4.2285
disp(i,"I_30(in amp)=(I_2)-(I_3)=")
disp("As (I_2-I_3) is positive , current floes in the
    assumed direction of I_2")
```

Scilab code Exa 1.13 find power

```
//example1.13
clc
disp("The various loop current are shown in the fig
   1.65(a). The problem consists of current sources
   hence follow supermesh steps.")
disp("Loops cannot be defined through current
   sources.So analyse the branches consisting of
   current sources first")
disp("From branch A-B we can write,")
disp("I_3=2A   ...(1)")
disp("From branch DG we can write,")
disp("I_2-I_1=8A   ...(2)")
disp("Now apply KVL to the loop without current
   source i.e.")
disp("loop C-D-E-H-G-F-C,")
disp("-(I_3)-(I_1)-3(I_3)-3(I_2)-4(I_2)+24=0")
disp("Therefore,  4(I_3)+7(I_2)+(I_1)=24   ...(3)")
disp("Using equation (1) and equation (2) in (3) we
   get,")
disp("8+7(I_2)+((I_2)-8)=24")
disp("Therefore  8(I_2)=24")
i=24/8
disp(i,"I_2(in amp)=")
disp("This is current through 4ohm resistor.So power
```

```
    deliverd to the 4ohm resistor is,")
p=9*4
disp(p,"P(in W)=((I_2)^2)*4=")
```

Scilab code Exa 1.14 find current

```
//example1.14
clc
disp("The various node voltages and currents are
    shown in the fig 1.72(a).")
disp("At node 1,   -(I_1)-(I_2)-(I_3)=0")
disp("Therefore,   -[(V_1-15)/1]-[V_1/1]-[(V_1-V_2)
    /0.5]=0")
disp("Therefore,   -(V_1)+15-(V_1)-2(V_1)+2(V_2)=0")
disp("Therefore,   4(V_1)-2(V_2)=15    ..(1)")
disp("At node 2,   (I_3)-(I_4)-(I_5)=0")
disp("Therefore,   [(V_1-V_2)/0.5]-[(V_2)/2]-[((V_2)
    +20)/1]=0")
disp("Therefore,   2(V_1)-2(V_2)-0.5(V_2)-(V_2)+20=0"
    )
disp("Therefore,   2(V_1)-3.5(V_2)= -20    ...(2)")
disp("Multiplying equation (2) by 2 and subtracting
    from equation (1) we get,")
disp("5(V_2)=55")
v=55/5
disp(v,"V_2(in V)= ")
v=(-20+(3.5*11))/2
format(5)
disp(v,"and,  V_1(in V)= ")
disp("Hence the various currents are,")
i=9.25-15
disp(i,"(I_1)(in A)=[(V_1)-5]/1=")
disp("i.e I1=5.75A  upward")
i=9.25/1
disp(i,"(I_2)(in A)=(V_1)/1=")
```

```
i=(9.25-11)/0.5
disp(i,"(I_3)(in A)=[(V_1)-(V_2)]/0.5=")
disp("i.e I3=3.5A to left")
i=11/2
disp(i,"(I_4)(in A)=(V_2)/2=")
i=11-20
disp(i,"(I_5)(in A)=[(V_2)-20]/1=")
disp("i.e I5=9A upward")
```

Scilab code Exa 1.15 node voltage

```
//example1.15
clc
disp("The various node voltage are shown in the fig
    1.73(a).")
disp("THe various braanch currents are shown.
    Applying KCL at various nodes.")
disp("Node 1:  9-I1-I2-I3=0   ..(1)")
disp("Node 1:  I3-I4+4=0   ..(2)")
disp("Node 1:  I2-4-I5=0   ..(3)")
disp("Key Point: Nodes V1 and V3 from supernode
    region and nodes V1 and V2 from super node region
    .")
disp("Super node: V1-10=V3  i.e.  V1-V3=10   ..(4)")
disp("Super node: V1+6=V2  i.e.  V1-V2=-6   ..(5)")
disp("From equation (2), I3=I4-4 and from equation
    (3), I2=I5+4")
disp("Using in equation (1), 9-I1-I5-4-I4+4=0")
disp("i.e  I1+I4+I5=9   ..(6)")
disp("I1=V1/4,  I4=V2/10,  I5=V3/5")
disp("Therefore   (V1/4)+(V2/10)+(V3/5)=9")
disp("i.e  0.25(V1)+0.1(V2)+0.2(V3)=9     ...(7)")
disp("Solving equations(4), (5) and (7)
    simultaneously,we get")
disp("0.25(V1)+0.1(V1+6)+0.2(V1-10)=9")
```

```
v=10.4/0.55
format(7)
disp(v,"Therefore,  V1(in V)=")
disp("putting V1 in eq.(4) and (5), we get ")
v=18.909+6
disp(v,"V2(in V)=")
v=18.909-10
disp(v,"V3(in V)=")
```

Scilab code Exa 1.16 instantaneous current

```
//example1.16
clc
disp("Case 1: R=10ohm")
disp("V=(V_m)sin(wt)")
v=150*sqrt(2)
format(7)
disp("(V_m)[in V]=sqrt(2)*V_rms=")
i=212.13/10
disp(i,"(I_m)[in A]=(V_m)/R=")
disp("In pure resistive circuit, currents is in
    phase with the voltage.")
disp("Therefore,  psi=phase difference= 0 degree")
disp("Therefore,  i=(I_m)sin(wt)=(I_m)sin(2*pi*f*t)"
    )
disp("Therefore,  i(in A) = 21.213sin(100*pi*t)")
disp("The phasor diagram is shown in the fig. 1.85(a
    )")
disp("Case 2:  L=0.2 ohm")
x=2*%pi*50*0.2
format(6)
disp(x,"Inductive reactance, (X_L)[in ohm]=wL=(2*pi*
    f*L)=")
i=212/13/62.83
format(5)
```

```
disp("Therefore,  (I_m)[in A]=(V_m)/(X_L)=")
disp("In pure inductive circuit, current lags voltage by 90 degree.")
disp("Therefore,  psi=phase difference = -90 degree =(pi/2)rad")
disp("Therefore,  i=(I_m)sin(wt-psi)  i.e.  i(in A) =3.37sin((100*pi*t)-(pi/2))")
disp("The phasor dig in shown in the fig 1.85(b).")
disp("Case 3:  C=50 micro-F")
c=1/(2*%pi*50*50*10^-6)
format(6)
disp(c,"Capacitive reactance,  X_c(in ohm)=1/wC =1/(2*pi*f*C)=")
i=212.13/63.66
format(5)
disp(i,"I_m(in A)=(V_m)/(X_c)=")
disp("In pure capacitive circuit, current leads voltage by 90 degree.")
disp("Therefore  psi=phase difference =90 degree= (pi/2)radian")
disp("Therefore,  i=(I_m)sin(wt+psi)")
disp("Therefore,  i(in A)=3.33sin((100*pi*t)+(pi/2))")
disp("The phasor dig is as shown in the fig 1.85(c).")
disp("All the phasor dig represent r.m.s values of voltage and current")
```

Scilab code Exa 1.17 find voltage

```
//example1.17
clc
r=10/10
disp(r,"R1(in ohm)=(2*5)/(2+5+3)=")
r=6/10
```

```
disp(r,"R2(in ohm)=(3*2)/(2+5+3)=")
r=15/10
disp(r,"R3(in ohm)=(5*3)/(2+5+3)=")
r=50/25
disp(r,"R1(in ohm)=(10*5)/(10+5+10)=")
r=100/25
disp(r,"R2(in ohm)=(10*10)/(10+5+10)=")
r=50/25
disp(r,"R3(in ohm)=(5*10)/(10+5+10)=")
disp("The circuit reduces as shown in the fig 1.86(c
   )")
r=0.6+4.2439+2
format(7)
disp(r,"R_ab(in ohm)=0.6+4.2439+2=")
disp("as, I=V/R_ab")
v=5*6.8439
format(8)
disp(v,"Therefore, V(in V)=I*R_ab=")
```

Scilab code Exa 1.18 equivalent resistance

```
//example1.18
clc
disp("Rearrange the circuit as shown below.")
disp("The 3.333ohm and 3.6ohm resistors are in
   series in fig 1.87(c).")
r=3.333+3.6
format(8)
disp(r,"Therefore, the equivalent resistance R_yz(in
    ohm)=")
```

Scilab code Exa 1.19 find current

```
//example1.19
clc
disp("Using the loop analysis, (fig 1.88(a) see on
   next page)")
disp("Applying KVL to the three loops,")
disp("-(I1)-(I1)-2(I1)+2(I3)+5-2(I1)=0  i.e  -6(I1)
   +2(I3)= -5    ...(1)")
disp("-2(I3)+2(I1)-2(I3)-5-2(I3)-(I3)+I2=0  i.e   2(
   I1)+I2-7(I3)=5    ...(2)")
disp("-2(I2)-(I2)+(I3)-2(I2)+5=0    i.e  -5(I2)+I3=
   -5  ...(3)")
disp("Solving equation (1),(2)and (3)")
disp("so, putting equations(1) and (3) in eq (2),we
   get")
disp("10(I3)+25+3(I3)+15-105(I3)=75")
disp("Therefore, -92(I3)=35")
i=(-35)/92
format(7)
disp(i,"Therefore, I3(in A)=")
disp("Now, putting value of I3 in equations (1) and
   (2) :")
i=((-35/46)+5)/6
disp(i,"Therefore, I1(in A)=")
i=((-35/92)+5)/5
disp(i,"and, I2(in A)=")
disp("These are the currents in all the sources. I3
   is negative hence its direction is opposite to
   that assumed earlier.")
```

Scilab code Exa 1.20 calculate resistance

```
//example1.20
clc
disp("The various branch currents are shown in the
   fig. 1.89. The current through branch OC is zero.
```

```
Applying KVL to the various loops,")
disp("-4(i2)-(R*i2)-2(i1)+10=0")
disp("i.e    2(i1)+4(i2)+(R*i2)=10      ..Loop AOBA")
disp("-(i1-i2)-1.5(i1-i2)-2(i1)+10=0")
disp("i.e    +4.5(i1)-2.5(i2)=10      ..Loop ACBA")
disp("-(i1-i2)-1.5(i1-i2)+(R*i2)+4(i2)=0")
disp("i.e    -2.5(i1)+6.5(i2)+(R*i2)=0      ..Loop ACBOA")
disp("As current through branch OC is zero, points O and C are equipotential. So drop across AO is same as drop across AC.")
disp("Therefore,     4(i2)=(i1-i2)     i.e     (i1)=5(i2)")
disp("Using in loop A-C-B-A, 4.5*5*(i2)-2.5(i2)=10")
i=10/20
disp(i,"Therefore,     i2(in A)=")
i=5*0.5
disp(i,"and, i1(in A)=")
disp("Using in loop A-O-B-A, (2*2.5)+(4*0.5)+0.5(R)=10")
r=3/0.5
disp(r,"Therefore,    R(in ohm)=")
disp("And current through R is i2=0.5 A")
```

Scilab code Exa 1.21 find current

```
//example1.21
clc
disp("Use nodal analysis,")
disp("Applying KCL at the two nodes,")
disp("21-I1-I2=0      (1)")
disp("I2-I3-I4=0      (2)")
disp("Analysing various branches,")
disp("I1=(V1-0)/2,    I2=(V1-V2)/3,    I3=(V2-0)/3,    I4=(V2-0)/6")
```

```
disp("Using in the equations (1) and (2),")
disp("21-(V1/2)-(V1-V2)/3 = 0")
disp("i.e   0.8333(V1)-0.333(V2) = 21     ...(3)")
disp("[(V1-V2)/3]-(V2/3)-(V2/6)=0")
disp("i.e   0.3333(V1)-0.8333(V2) = 21     ...(4)")
disp("Solving equations (3) and (4),")
disp("0.8333(V1)-0.333(0.3333/0.8333)V1=21")
v=(-21*0.8333)/((0.333*0.3333)-(0.8333)^2)
format(3)
disp(v,"V1(in V)=")
v=(0.3333*30)/0.8333
disp(v,"V2(in V)=")
i=-12/6
disp(i,"Therefore, I(in 6ohm)=I4(in A)=")
disp("The current flows in downward direction in 6
    ohm resistor.")
disp("Voltage across current soource is the voltage
    across 2ohm resistance, which is node voltage V1
    =30 V.")
p=30*21
format(4)
disp(p,"Therefore, power supplied by source P(in W)=
    V1*21=30*21=")
```

Scilab code Exa 1.22 find voltage

```
//example1.22
clc
disp("The arrangment is shown in the fig 1.92")
disp("P2=(I^2)*R2")
disp("Therefore, 16= (2^2)*R2")
r=16/4
disp(r,"R2(in ohm)=")
v=4*2
disp(v,"V2(in ohm)=I*R2=")
```

```
v=2*6
disp("V3(in V)=I*R3=")
v=4+8+12
disp(v,"V(in V)=V1+V2+V3=")
```

Scilab code Exa 1.23 find current

```
//example1.23
clc
disp("The branch currents are shown in the fig 1.93(a)")
disp("Applying KVL to the two loops,")
disp("-2(I1)-5(I2)+12=0")
disp("i.e   2(I1)+5(I2)=12   ..(1)")
disp("-4(I1-I2)-6(I1-I2)+5(I2)=0")
disp("i.e   -10(I1)+15(I2)=0")
disp("Solving equation (1) and (2),")
disp("2(I1)+5(10/15)(I1)=12")
i=9/4
format(5)
disp(i,"I1(in A)=")
disp("put this value of I1 in eq (2),we get")
i=(10/15)*2.25
disp(i,"I2(in A)=(10/15)*2.25=")
disp("    Branch          Current            voltage drop")
disp("      A-B           I1=2.25A             2(I1)=4.5V")
disp("      B-C         I1-I2=0.75A           4(I1-I2)=3V")
disp("      C-D         I1-I2=0.75A           6(I1-I2)=4.5V")
disp("      B-E            I2=1.5A              5(I2)=7.5V")
disp("      F-A           I1=2.25A             12V source"
```

```
)
```

Scilab code Exa 1.24 find voltage drop

```
//example1.24
clc
i=20/(2+1.2727)
format(7)
disp(i,"I(in A)=")
disp("By current division rule,")
i=(6.1111*2)/5.5
format(6)
disp(i,"I1(in A)=9(I*2)/(2+3.5)=")
v=2.222*1
disp(v,"V(1 ohm)=I1*1=")
i=(6.1111*3.5)/5.5
disp(i,"I2(in A)=(3.5*I)/(2 +3.5)=")
p=((3.888)^2)*2
format(7)
disp(p,"P(2 ohm)[in W]=(I2^2)*2=")
```

Scilab code Exa 1.25 find inductive resistance

```
//example1.25
clc
disp("The arrangement is shown in the fig 1.97.")
x=110/10
disp(x,"X_L(in ohm)=V/I=")
disp("THe inductive reactance is 11 ohm")
disp("X_L=2*pi*f*L")
disp("Therefore, 11=2*pi*50*L")
l=11/(2*%pi*50)
format(9)
```

```
disp(l,"L(in H)=")
```

Scilab code Exa 1.26 find resistance

```
//example1.26
clc
disp("For d.c. supply frequency is 0 Hz.")
disp("X_C=1/(2*pi*f*C)=1/0=infinity")
disp("So capacitor gives infinite reactance in d.c.
    supply and acts as an open circuits.")
disp("In an a.c. supply of 100 Hz,")
x=1/(2*%pi*100*50*10^-6)
format(9)
disp(x,"X_C(in ohm)=1/(2*pi*f*C)=")
```

Scilab code Exa 1.27 find resistance

```
//example1.27
clc
disp("The circuit can be redrawn as shown in the fig
    1.99(a)")
disp("fig 1.99(a,b) see on next page")
disp("Therefore, R_eq=[30(10+R)/(30+10+R)]=(300+30R)
    /(40+R)")
disp("Therefore, I=V/(R_eq)    i.e    6=30/[(300+30R)
    /(40+R)]")
disp("6(300+30R)=50(40+R)    i.e.    1800+180R
    =2000+50R")
r=200/130
format(7)
disp(r,"R(in ohm)=")
disp("By current division rule,")
i=(6*11.5384)/41.5384
```

```
format(6)
disp(i,"I1(in A)=[(I_t)*(10+R)/(10+R+30)]=")
i=(6*30)/41.5384
disp(i,"I2(in A)=[(I_t)*30/(10+R+30)]=")
disp("Key point: Cross check I1+I2= 6 A")
```

Scilab code Exa 1.28 find resistance

```
//example1.28
clc
disp("Convert the delta of 2ohm, 3ohm and 5ohm to
   equivalent star as shown in the fig 1.101(a)")
r=15/10
disp(r,"R1(in ohm)=(5*3)/(5+3+2)=")
r=6/10
disp(r,"R2(in ohm)=(3*2)/(5+3+2)=")
r=10/10
disp(r,"R3(in ohm)=(5*2)/(5+3+2)=")
disp("Convert the delta of 1ohm, 5.6ohm and 4ohm to
   equivalent star as shown in the fig 101(c)")
r=5.6/10.6
format(7)
disp(r,"R4(in ohm)=(5.6*1)/(1+5.6+4)=")
r=(5.6*4)/10.6
disp(r,"R5(in ohm)=(5.6*4)/(1+5.6+4)=")
r=4/10.6
disp(r,"R6(in ohm)=(1*4)/(1+5.6+4)=")
r=3.4705+0.3773
disp(r,"Therefore, R_ab(in ohm)=3.4705+0.3773=")
```

Scilab code Exa 1.29 find resistance

```
//example1.29
```

```
clc
disp("Convert the inner delta of 5ohm to equivalent star. As all the resistances of delta are same, all the resistances of equivalent star will be equal of value ")
r=25/15
disp(r,"R(in ohm)=(5*5)/(5+5+5)=")
disp("Convert the delta of 6.667ohm, 5ohm and 11.667 ohm")
r=(6.667*11.667)/(6.667+11.667+5)
format(7)
disp(r,"R1(in ohm)=(6.667*11.667)/(6.667+11.667+5)=")
r=(6.667*5)/(6.667+11.667+5)
disp(r,"R2(in ohm)=(6.667*5)/(6.667+11.667+5)=")
r=(5*11.667)/(6.667+11.667+5)
format(7)
disp(r,"R3(in ohm)=(5*11.667)/(6.667+11.667+5)=")
r=5.333+2.612
format(7)
disp(r,"Therefore,  R_ab(in ohm)=5.333+2.612=")
```

Scilab code Exa 1.30 find current

```
//example1.30
clc
disp("Let us divide the voltage waveform into two sections.")
disp("For 0<=t<=2, v(t)=mt  where,")
m=10/2
disp(m,"m=(10-0)/(2-0)=")
disp("Therefore,  i(t)=v(t)/R=5t/40=0.125t A")
i=0.125*2
disp(i,"At t=2, v(t)=10 V,  i(t)[in A]=0.125*2=")
m=(-10)/2
```

```
disp(m,"For 2<=t<=4, v(t)=mt+c    where    m=(0-10)/(4-2)=")
disp("Therefore,    v(t)= -5t+C")
c=5*4
disp(c,"Now at t=4,  v(t)=0  i.e.  0= -5*4+C   i.e   C=")
disp("Therefore,    v(t)= -5t+20")
disp("Therefore,    i(t)=v(t)/R= (-5t+20)/40= -0.125t+0.5")
disp("At t=4, v(t)= -5*4+20=0 V,  i(t)= -0.125*4+0.5= 0 V")
disp("Hence the waveform of the current passing through the resistance is as shown in the fig 1.105")
```

Scilab code Exa 1.31 obtain current

```
//example1.31
clc
disp("Method 1: Kirchoffs laws")
disp("Now apply KVL to the two loops without current source as effect of the currents in various branches.")
disp("-2(I1-2)-I2+6=0   i.e.    2(I1)+I2=10    ..(1)")
disp("-3(I1-2-I2)-12+I2=0   i.e.    -3(I1)+4(I2)=6   ..(2)")
disp("-3(I1)+4(10-2(I1))=6")
i=34/11
format(7)
disp(i,"Therefore,    I1(in A)=")
i=10-(2*3.0909)
disp(i,"and,   I2(in A)=")
disp("Currents through various resistances are,")
i=3.0909-2
```

```
disp(i,"I(2ohm)[in A]=I1-2=")
disp("I(1ohm)[in A]=I2=3.8181")
i=3.0909-2-3.8181
disp(i,"I(3ohm)[in A]=I1-2-I2=")
disp("Current through 3ohm is negative i.e. it is
    flowing in opposite direction to that assumed in
    the circuit.")
disp("Method II: Loop analysis")
disp("From the current source branch,")
disp("I3= 2 A")
disp("Applying KVL to the other two loopos without
    current source,")
disp("-2(I1)+2(I3)-I1+I2+6=0     i.e.     -3(I1)+I2=
    -10   ..(1)")
disp("-3(I2)+3(I3)-12-I2+I1=0    i.e.     I1-4(I2)=6
    ..(2)")
disp("Solving we get,")
disp("I1-4(-10+3(I1))=6")
i=34/11
disp(i,"I1(in A)=")
i=(3.0909-6)/4
disp(i,"and,  I2(in A)=")
disp("Currents through various resistances are,")
i=3.0909-2
disp(i,"I(2ohm)[in A]=I1-2=")
i=3.0909+0.7272
disp(i,"I(1ohm)[in A]=I1-I2=")
i=-0.7272-2
disp(i,"I(3ohm)[in A]=I2-2=")
disp("The currents are same as obtained by the
    method 1.")
```

Scilab code Exa 1.32 calculate current

```
//example1.32
```

```
clc
disp("Use the loop analysis")
disp("From the current source branch,")
disp("I3=1 A")
disp("Applying KVL to the loops without current source we get,")
disp("-6(I1)-4-5(I1)+5(I2)=0    i.e.    -11(I1)+5(I2)=4  ..(1)")
disp("-5(I2)+5(I1)-6-4(I2)-4(I3)=0  i.e.    5(I1)-9(I2)=10  (2)")
disp("Solving, we get:")
disp("-11(I1)+5((5I1-10)/9)=4")
disp("Therefore,    -99(I1)+25(I1)-50=36")
i=86/(-74)
format(7)
disp(i,"Therefore,      I1(in A)=")
i=((5*(-1.1621))-10)/9
disp(i,"and,    I2(in A)=")
disp("Current through 5ohm in specified direction is,")
i=(-1.7567+1.1621)
disp(i,"I(5ohm)[in A]=I2-I1= -1.7567-(-1.1621)=")
disp("As negative, current through 5ohm flows in opposite direction to that specified in the circuit.")
```

Chapter 2

DC Machines

Scilab code Exa 2.1 generated emf

```
//example2.1
clc
disp("P=4    Z=440    psi=0.07 Wb    and    N=900 r.p.m.
  ")
disp("E=(psi*P*N*Z)/(6*A)")
disp("i)For lap wound,        A=P=4")
e=(0.07*900*440)/60
disp(e,"Therefore,     E(in V)=(psi*N*Z)/60=")
disp("ii)For wave wound,       A=2")
e=(0.07*900*4*440)/120
disp(e,"Therefore,     E(in V)=(psi*P*N*Z)/120=")
```

Scilab code Exa 2.2 generated emf and speed

```
//example2.2
clc
disp("P=4    psi=21 mWb=21*10^-3 Wb,    N=1120r.p.m")
disp("Coils = 42 and turns/coil = 8")
```

```
t=42*8
disp(t,"Total turns = coil * turns/coil = 42*8 =")
z=2*336
disp(z,"Z= 2*total turns = 2*336 =")
disp("i) for lap wound, A=P")
e=(21*1120*672*10^-3)/60
format(8)
disp(e,"Therefore,  E(in V)=(psi*N*Z)/60=")
disp("ii) For wave wound, A=2")
disp("and,  E=263.424 V")
disp("Therefore,    E=(psi*P*N*Z)/120")
n=263.424*120/(21*4*672*10^-3)
disp(n,"N(in rpm)=")
```

Scilab code Exa 2.3 induced emf of generator

```
//example2.3
clc
disp("Consider shunt generator as shown in the fig
   2.29")
disp("I_a=(I_L)+(I_sh)")
disp("I_sh=(V_t)/(R_sh)")
disp("Now,  V_t=250 V")
disp("and,  R_sh=100 ohm")
i=250/100
disp(i,"Therefore,    I_sh(in A)=")
disp("Load power=5 kW")
disp("Therefore,    P=(V_t)*(I_L)")
i=(5*10^3)/250
disp(i,"I_L(in A)=P/(V_t)=")
i=20+2.5
disp(i,"(I_a)[in A]=(I_L)+(I_sh)=")
disp("E=(V_t)+((I_a)*(R_a))[neglect V_brush]")
E=250+(22.5*0.22)
disp(E,"Therefore,    E(in V)=")
```

```
disp("This is the induced emf to supply the given load.")
```

Scilab code Exa 2.4 armature resistance of generator

```
//example2.4
clc
disp("Consider separately excited generator as shown in the fig 2.30")
disp("Note that 250V, 10kW generator means the full load capacity of generator is to supply 10kW load at a terminal voltage V_t=250 V")
disp("Therefore,    V_t=250V    and    P=10kW")
disp("and,  P=(V_t)*(I_L)")
i=(10^4)/250
disp(i,"Therefore,    I_L(in A)=")
disp("Therefore,    I_a=I_L= 40 A    ...As separately excited")
disp("Now,  E=(V_t)+[(I_a)*(R_a)]+(V_brush)")
disp("Now there are two brushes and brush drop is 2V/brush")
v=2*2
disp(v,"Therefore,    V_brush(in V)=")
disp("Therefore,    E=250+40(R_a)+4")
disp("But,  E=255 V on full load")
disp("255 = 250 + 40(R_a) + 4")
r=1/40
disp(r,"Therefore,    R_a(in ohm)=")
```

Scilab code Exa 2.5 terminal voltage at load

```
//example2.5
clc
```

```
disp("Consider the series generator as shown in fig 2.31")
disp("R_a=0.5 ohm        and       R_se=0.03 ohm")
disp("V_brush=2 V")
disp("N=1500 rpm")
disp("Total coils are 540 with 6 turns/coil.")
t=540*6
disp(t,"Therefore,      Total turns =540*6=")
disp("Total conductors Z= 2* turns")
z=2*3240
disp(z,"z=2*3240=")
disp("Therefore,      E=(psi*P*N*Z)/(60*A)")
disp("For lap type, A=P")
disp("psi=2 mWb=2*10^-3 Wb")
e=(1500*6480*2*10^-3)/60
disp(e,"Therefore,      E(in V)=")
disp("E=(V_t)+(I_a)[(R_a)+(R_sc)]+(V_brush)        .. Total V_brush given")
disp("Where,       I_a=I_L=50 A")
disp("324=(V_t)+50(0.5+0.03)+2")
v=322-(50*(0.53))
disp(v,"V_t(in V)=")
```

Scilab code Exa 2.6 generated voltage

```
//example2.6
clc
disp("Consider a short shunt generator as shown in the fig 2.32")
disp("R_a=0.04 ohm,     R_sh=90 ohm,     R_se=0.02 ohm")
disp("V_t=225 V  ,     I_L=75 A")
disp("I_a = I_L + I_sh")
disp("Now,          E=(V_t)+[(I_a)*(R_a)]+[(I_L)*(R_se)]")
disp("and drop across armature terminals is,")
```

```
disp("E-[(I_a)*(R_a)]=(V_t)+[(I_t)*(R_se)]")
e=225+(75*0.02)
disp(e,"Therefore,    E-[(I_a)*(R_a)]=")
disp("Therefore,    I_sh=[E-(I_a)(R_a)]/(R_sh)=[(V_t
    )+(I_L)(R_se)]/(R_sh)")
i=226.5/90
format(7)
disp(i,"Therefore,    I_sh(in A)=")
i=75+2.5167
disp(i,"Therefore,    I_a=I_L+I_sh=")
disp("Therefore,    E=V_t+[(I_a)*(I_sh)]+[(I_L)*(
    R_se)]")
e=225+(77.5167*0.04)+(75*0.02)
format(6)
disp(e,"E(in V)=")
```

Scilab code Exa 2.7 induced emf in motor

```
//example2.7
clc
disp("V=200 V, I_a=30 A, R_a=0.75 ohm are the given
    values.")
disp("For a motor,  V=(E_b)+[(I_a)*(R_a)]")
disp("Therefore,    220=(E_b)+(30*0.75)")
e=220-(30*0.75)
disp(e,"E_b(in V)=")
disp("This is the induced emf called back emf in a
    motor")
```

Scilab code Exa 2.8 back emf and speed of motor

```
//example2.8
clc
```

```
disp("P=4,  A=P=4 as lap,  V=230 V,  Z=250")
disp("psi=30mWb=30*10^-3 Wb,     I_a=40 A")
disp("From voltage equation,    V=E_b+[(I_a)*(R_a)]"
   )
disp("230=E_b+(40*0.6)")
e=230-(40*0.6)
disp(e,"Therefore,    E_b(in V)=")
disp("E_b=(psi*P*N*Z)/(60*A)")
disp("Therefore,    206=(4*N*250*30*10^-3)/(60*4)")
n=(206*240)/(250*4*30*10^-3)
disp(n,"N(in rpm)=")
```

Scilab code Exa 2.9 gross torque

```
//example2.9
clc
disp("P=4, A=P=4, Z=480")
disp("psi=20mWb=20*10^-3 Wb,  I_a=50 A")
t=(0.159*0.02*50*4*480)/4
format(7)
disp(t,"Now,   T_a(in N-m)=0.159*(psi)*(I_a)*(P*Z)/A=
   ")
```

Scilab code Exa 2.10 induced emf and armature current and stray losses and lost torque

```
//example2.10
clc
disp("P=4,  A=P=4")
disp("Running light it is on no load.")
disp("Therefore,    N_0=1000 rpm    Z=540    and    psi
   =25*10^-3 Wb")
e=(100*540)/240
```

```
disp(e,"Therefore,  E_b0(in V)=(psi*P*N*Z)/(60*A)=")
disp("i)Induced emf,    E_b0=225 V")
disp("ii) From voltage equation,     V=(E_b)+[(I_a)*(R_a)]")
disp("V=(E_b0)+[(I_a0)*(R_a)]")
disp("230=225+[(I_a0)*0.8]")
i=5/0.8
disp(i,"I_a0(in A)=")
disp("iii) On no load,power developed is fully the power required to overcome stray losses.")
e=225*6.25
format(8)
disp(e,"Stray losses=(E_b0)*(I_a0)=")
t=(1406.25*60)/(2*%pi*1000)
format(7)
disp(t,"T_f(in N-m)=[(E_b0)*(I_a0)]/(w_0)=")
```

Scilab code Exa 2.11 speed of motor

```
//example2.11
clc
disp("P=4,  Z=200,  A=2,   psi=25*10^-3 Wb")
disp("(I_a)=(I_L)=60 A,      R_a=0.15ohm,      R_se=0.2 ohm")
disp("V=(E_b)+(I_a*R_a)+(I_a*R_se)")
disp("250=E_b+60(0.15+0.2)")
b=250-(60*(0.15+0.2))
disp(b,"E_b(in V)=")
disp("Now,  E_b=(psi*P*N*Z)/(60*A)")
disp("Therefore,    229=(25*(10^-3)*4*N*200)/(60*2)")
n=(229*60*2)/(800*25*10^-3)
disp(n,"Therefore, N(in rpm)=")
```

Scilab code Exa 2.12 armature current and back emf

```
//example2.12
clc
disp("V=250 V,   I_L=20 A,     R_s=0.3ohm,    R_sh=200
   ohm")
disp("I_L=(I_a)+(I_sh)")
s=250/200
disp(s,"(I_sh)[in A]=V/(R_sh)=")
disp("Therefore,     I_a=(I_L)-(I_sh)")
a=20-1.25
disp(a,"I_a(in A)=20-1.25=")
disp("Now,  V=(E_b)+(I_a*R_a)")
disp("Therefore,     E_b=V-[(I_a)*(R_a)]")
b=250-(18.75*0.3)
format(8)
disp(b,"E_b(in V)")
```

Scilab code Exa 2.13 speed on full load

```
//example2.13
clc
disp("Let no load,speed be N_0=1000 rpm")
disp("I_L0=Line current on no load=6 A")
disp("I_L0=(I_a0)+(I_sh)")
s=220/110
disp(s,"(I_sh)[in A]=V/(R_sh)=")
a=6-2
disp(a,"Therefore,  (I_a0)[in A]=(I_L0)-(I_sh)=")
disp("Therefore, Back emf on no load E_b0 can be
   determined from the voltage equation.")
disp("V=(E_b0)+[(I_a0)+(R_a)]")
```

```
disp("Therefore,     220=(E_b0)+(4*0.3)")
b=220-1.2
disp(b,"E_b0(in V)=")
disp("On full load condition,supply voltage is constant and hence,")
s=220/110
disp(s,"(I_sh)[in A]=V/(R_sh)=")
disp("Now,(I_L)=(I_aFL)+(I_sh)")
disp("Therefore,     50=(I_aFL)+2")
f=50-2
disp(f,"Therefore,   (I_aFL)[in A]=")
disp("And,   V=(E_bFL)+[(I_aFL)*(R_a)]")
disp("Therefore,     220=(E_bFL+(48*0.3))")
b=220-(48*0.3)
disp(b,"Therefore,     (E_bFL)[in V]=")
disp("From the speed equation,")
disp("N directly proportional to (E_b)/psi")
disp("But psi is constant as I_sh is constant for both the load conditions")
disp("Therefore,     (N_0)/(N_FL)=(E_b0)/(E_bFL)")
n=(1000*205.6)/218.8
format(7)
disp(n,"Therefore,     (N_FL)[in rpm]=[(N_0)*(E_bFL)]/(E_b0)=")
```

Scilab code Exa 2.14 speed of motor on new load

```
//example2.14
clc
disp("For load 1, N1=800 rpm,    I1=(I_a1)=20A")
disp("For load 2,    I2=(I_a2)=50 A,   R_a=0.2 ohm, R_se=0.3 ohm")
disp("From voltage equation V=(E_b1)+[(I_a1)*(R_a)]+[(I_se1)*(R_se)]")
disp("but    I1=(I_a1)=(I_se1)=20 A")
```

```
disp("Therefore,    250=(E_b1)+20(0.2+0.3)")
b=250-10
disp(b,"Therefore,    E_b1(in V)=")
disp("and,  V=(E_b2)+[(I_a2)*R_a]+[(I_se2)+(R_se)]")
disp("Therefore,    250=(E_b2)+50(0.2+0.3)")
b=250-25
disp(b,"E_b2(in V)=")
disp("From the speed equation,")
disp("N is directly proportional to (E_b)/psi")
disp("Now,  psi proportional to (I_se) and (I_a)")
disp("Therefore,    N1/N2=[(E_b1)*(psi_2)]/[(E_b2)*(psi_1)]")
disp("Therefore,    N1/N2=[(E_b1)*(I_a2]/[(E_b2)*(I_a1)]")
n=(800*225*20)/(240*50)
disp(n,"Therefore,    N2(in rpm)=[(N1)*(E_b2)*(I_a1)]/[(E_b1)*(I_a2)]=")
```

Scilab code Exa 2.15 terminal voltage

```
//example2.15
clc
disp("Consider the generator as shown in fig 2.61")
disp("P=4,  A=P=4,  N=750 rpm,   psi=30 mWb=30*10^-3,    Z=720")
n=(4*750*720*30*10^-3)/(240)
disp(n,"E(in V)=(psi*P*N*Z)/(60*A)=")
disp("E=(V_t)+[(I_a)*(R*a)]")
disp("(V_t)=(I_L)*(R_L)      i.e.     I_L=(V_t)/(R_L)")
disp("And,  I_sh=(V_t)/(R_sh)")
disp("I_a=(I_L)+(I_sh)=[(V_t)/(R_L)]+[(V_t)/(R_sh)]")
disp("Substituting in voltage equation,")
disp("E=(V_t)+[(V_t)/(R_L)+(V_t)/(R_sh)]*(R_a)")
```

```
disp("Therefore,    270=(V_t)+[(V_t)/(15)+(V_t)
    /(200)]*(0.4)")
disp("270=1.0286(V_t)")
v=270/1.0286
format(9)
disp(v,"V_t(in V)=")
```

Scilab code Exa 2.16 full load output and efficiency of motor

```
//example2.16
clc
disp("No load current I=2.5 A,")
n=440*2.5
disp(n,"No load input(in W)= (V*I)=")
s=440/550
disp(s,"I_sh(in A)=V/R_sh=")
disp("In dc shunt motor,    I=(I_sh)+(I_a)")
a=2.5-0.8
disp(a,"I_a(in A)=I-(I_sh)=")
p=1.2*(1.7)^2
format(6)
disp(p,"No load armature copper loss(in watts)= (R_a
    )*(I_a)^2=")
disp("Constant losses= No load input- No lpad
    armature Cu losses")
c=1100-3.468
format(9)
disp(c,"Therefore,    Constant losses(in Z)=")
disp("Now, full load line current i.e I=32 A")
disp("I=(I_sh)+(I_a)")
a=32-0.8
disp(a,"I_a(in A)=I-(I_sh)=")
p=1.2*(31.2)^2
disp(p,"Full load armature copper loss=(R_a)*(I_a)
    ^2=")
```

```
disp("Total losses= Full load armature Cu loss + Constant losses")
l=1168.128+1096.532
disp(l,"Therefore, Total losses(in W)=")
v=440*32
disp(v,"Full load motor input(in W)= V*I =")
v=14080-2264.66
disp(v,"Full load motor output(in W)= Input-Losses=")
d=(1181534)/14080
format(6)
disp(d,"% efficiency at full load= [(Full load Output)/(full load input)]*100=")
disp("Therefore,    Efficiency of motor at full load = 83.91%")
```

Scilab code Exa 2.17 armature current and back emf and speed of motor

```
//example2.17
clc
disp("R_a=0.08 ohm, E_b1=242 V")
disp("i)    V=(E_b1)+[(I_a1)*(R_a)]")
disp("Therefore,    250=242+[(I_a1)*0.08]")
a=8/0.08
disp(a,"I_a1(in A)=")
disp("ii)   At start,   N=0 hence E_b=0")
a=250/0.08
disp(a,"(I_a(start))[in A]=V/(R_a)=")
disp("iii)  If  (I_a2)=120 A then,")
b=250-(120*0.08)
disp(b,"E_b2(in V)=V-[(I_a2)*(R_a)]=")
disp("iv)   Machine is running as a generator, shown in the fig 2.62")
disp("Let induced emf as generator be E_g")
g=250+(87*0.08)
```

```
format(7)
disp(g,"E_g(in V)=(V_t)+[(I_a)*(R_a)]=")
disp("In both cases as a motor or genrator E is
    directly prportional to (N*psi)")
disp("As flux is constant,  E is directly
    proportional to N")
disp("Therefore,     (E_b/E_g)=(N_m/N_g)")
disp("where      N_m= Speed as a motor   and     N_g=
    Speed as a generator")
disp("Therefore,     (242/256.96)=(1500/N_g)")
n=(1500*256.96)/242
disp(n,"N_g(in rpm)=")
```

Scilab code Exa 2.18 extra resistance to be added

```
//example2.18
clc
disp("V=200 V, I_a1=30 A")
disp("Resistance across terminals=(R_a)+(R_se)=1.5
    ohm")
b=200-45
disp(b,"Therefore,     E_b1(in V)=V-[(I_a1)*(R_a-R_se
    )]=")
disp("N2=0.6(N1)")
disp("Therefore,     (N1/N2)=(1/0.6)")
disp("Use torque equation,")
disp("T is directly proportional to (psi*I_a) and (
    I_a)^2")
disp("as  ...  psi is directly proportional to I_a")
disp("Therefore,     (T1/T2)=[(I_a1)/(I_a2)]^2
    ..(1)")
disp("Also T is directly proportional to N^3 given,"
    )
disp("(T1/T2)=(N1/N2)^3=(1/0.6)^3    ..(2)")
disp("Equatimg equation (1) and (2),  (1/0.6)^3 =
```

```
    (30/I_a2)^2")
a=sqrt(900*(0.6^3))
format(8)
disp(a,"Therefore,    I_a2(in A)=")
disp("E_b2=V-[(I_a2)*(R_a+R_se+R_x)
    ]=200-13.9427(1.5+R_x)    ..(3)")
disp("Use speed equation,   N directly proportional
    to [(E_b)/psi] and [(E_b)/(I_a)]         ... psi
    id directly proportional to I_a")
disp("Therefore,    (N1/N2)=[(E_b1)/(E_b2)]*[(I_a2)
    /(I_a1)]")
disp("Therefore,    (1/0.6)=(155/E_b2)*(13.9427/30)"
    )
b=155*0.139427*2
format(6)
disp(b,"E_b2(in V)=")
disp("Equating equations (3) and (4),
    43.22=200-13.9427(1.5+R_x)")
r=[(200-43.22)/13.9427]-1.5
disp(r,"R_x(in ohm)=")
```

Scilab code Exa 2.19 efficiency of motor

```
//example2.19
clc
disp("No load current = I_L0 = 4 A")
s=250/250
disp(s,"I_sh[in A]=V/(R_sh)=")
a=4-1
disp(a,"Therefore,   I_a0(in A)=(I_L0)-(I_sh)=")
r=0.3*(3)^2
disp(r,"Therefore,    No. load armature copper loss(
    in W)=[(I_a0)^2*(R_a)]=")
o=250*4
disp(o,"No load input(in W) = V*I_L0 =")
```

```
c=1000-2.7
disp(c,"Constant losses(in W) = No load input-No
    load armature copper loss=")
disp("On full load,      I_L=60 A and I_sh=1 A")
j=60-1
disp(j,"Therefore,      I_a(in A)=(I_L)-(I_sh)=")
l=0.3*(59)^2
disp(l,"Full load armature copper loss(in W)= (I_a
    ^2)*R_a=")
l=997.3+2041.6
disp(l,"Total loss on full load=constant losses+ [(
    I_a)^2*(R_a) loss]=")
disp("Total input on full load = V*(I_L)")
l=250*60
disp(l,"Therefore,      P_in(in W)=")
p=15000-2041.6
format(8)
disp(p,"(P_out)[in W]=(P_in)-Total loss=")
n=1295840/15000
format(7)
disp(n,"% efficiency(n)=[(P_out)*100]/(P_in)=")
```

Scilab code Exa 2.20 lap and wave wound

```
//exmaple1.20
clc
disp("P=6, Z=780, E_g=500V, N=1000 rpm")
disp("a) Lap wound,   A=P=6")
disp("(E_g)=(psi*P*N*Z)/(60*A)     i.e.     500=(psi
    *6*1000*780)/(60*6)")
s=(500*60*6)/(6*1000*780)
format(8)
disp(s,"Therefore,   psi(in Wb)=")
disp("b) Wave wound,   A=2")
disp("(E_g)=(psi*P*N*Z)/(60*A)     i.e.     500=(psi
```

```
*6*1000*780)/(60*2)")
s=(500*60*2)/(6*1000*780)
disp(s,"Therefore,  psi(in Wb)=")
```

Scilab code Exa 2.21 emf generated

```
//example2.21
clc
disp("P=6, psi=0.02 Wb, N=1000 rpm, A=P as lap wound
")
z=65*12
disp(z,"Z=slots*conductors/slot=")
g=(0.02*6*1000*780)/(60*6)
disp(g,"E_g(in V)=(psi*P*N*Z)/(60*A)=")
```

Scilab code Exa 2.22 speed of generator

```
//example2.22
clc
disp("P=4, A=2, psi=0.0121 Wb, Z=792, E_g=240 V")
disp("(E_g)=(psi*P*N*Z)/(60*A)     i.e.
240=(0.0121*4*N*792)/(60*2)")
n=(480*60)/(792*4*0.0121)
format(9)
disp(n,"Therefore,        N(in rpm)=")
```

Scilab code Exa 2.23 induced voltage

```
//example2.23
clc
```

```
disp("The generator is shown in the fig 2.64")
disp("The current through R_se is I_L=80 A as the
    generator is short shunt.")
disp("The drop across R_sh is the sum of the drop
    across R_se and V_t")
disp("[(I_sh)*(R_sh)]=(V_t)+[(I_L)*(R_se)]")
disp("i.e   100(I_sh)=250+(80*0.03)")
p=2.5+(0.8*0.03)
format(6)
disp(p,"(I_sh)[in A]=")
a=80+2.524
format(7)
disp(a,"(I_a)[in A]=(I_L)+(I_sh)=")
g=250+(82.524*0.05)+(80*0.03)+2
format(9)
disp(g,"E_g(in V)=(V_t)+[(I_a)*(R_a)]+[(I_L)*(R_se)
    ]+Brush drop")
```

Scilab code Exa 2.24 commutator bars

```
//example2.24
clc
disp("P=4, Lap hence A=P, N=1150 rpm, E_g=265 V")
n=56*6
disp(n,"Total turns=No. of coils*turns/coil=")
z=2*336
disp(z,"Therefore,    Z=2*total turns=")
disp("E_g=(psi*P*N*Z)/(60*A)   i.e  265=(psi
    *4*1150*672)/(60*A)")
s=(265*60*4)/(4*1150*672)
disp(s,"Therefore,  psi(in Wb)=")
disp("Number of commutator bars=Number of coils=56")
```

Scilab code Exa 2.25 induced emf

```
//example2.26
clc
disp("For a d.c. generator,")
disp("E_g=(psi*N*P*Z)/(60*A)    i.e    E_g is
    directly proportional to (psi*N)      ... (P*Z)
    /(60*A) is constant")
disp("N1=1000 rpm, (psi_1)=0.02 Wb, (E_g1)-200 V, N2
    =1100 rpm, (psi_2)=0.019 Wb")
disp("[(E_g1)/(E_g2)]=[(N1*psi_1)/(N2*psi_2)]   i.e
    [(200)/(E_g2)]=[(1000*0.02)/(1100*0.019)]")
g=(200*1100*0.019)/(1000*0.02)
disp(g,"Therefore,  E_g2(in V)=")
```

Scilab code Exa 2.26 total and useful torque and flux and rotational losses and efficiency

```
//example2.26
clc
disp("P=4, V=240 V, A=2 as wave, N=1000 rpm, P_out
    =11.19 kW")
disp("I_a=50 A, I_sh=50 A, R_a=0.1 ohm, Z=540")
disp("a) E_b=V-[(I_a)(R_a)]-Brush drop")
b=240-(50*0.1)-2
disp(b,"E_b(in V)=")
t=(233*50*60)/(2*%pi*1000)
format(9)
disp(t,"Therefore,  T(in Nm)=[(E_b)(I_a)]/w=[(E_b)(
    I_a)]/[(2*pi*N)/60]=")
t=(11190*60)/(2*%pi*1000)
disp(t,"b)  T_sh(in Nm)=useful torque=(P_out)/w=")
disp("c) E_b=(psi*P*N*Z)/(60*A)    i.e    233=(psi
    *4*100*540)/(60*2)")
p=(233*60*2)/(4000*540)
```

```
format(6)
disp(p,"Therefore,     psi(in Wb)=")
disp("Rotational losses= (T-T_sh)*w= (T-T_sh)*(2*pi*
   N)/60")
i=[(111.2493-106.8566)*(2*%pi*1000)]/60
format(4)
disp(i,"Therefore, Rotational losses(in W)=")
p=240*51
format(7)
disp(p,"P_in(in W)=V*(I_L)=V*(I_a+I_sh)=")
n=(11190*100)/12240
format(6)
disp(n,"% efficiency =[(P_out)*100]/(P_in)=")
```

Scilab code Exa 2.27 speed

```
//example2.27
clc
disp("V=250 V, N_0=1000 rpm, I_L0=5 A, R_a=0.2 ohm,
    R_sh=250 ohm")
i=250/250
disp(i,"I_sh(in A)=(V/R_sh)=")
i=5-1
disp(i,"Therefore, I_a0(in A)=(I_L0)-(I_sh)=")
e=250-(4*0.2)
disp(e,"E_b0(in V)=V-[(I_a0)(R_a)]=")
disp("on load, I_L1=50 A, (psi_1)=(psi_0)-(3% of (
    psi_0))=0.97(psi_0)")
disp("I_sh remains constant as long as V and R_sh
    are constant.")
i=50-1
disp(i,"I_a1(in A)=(I_L1)-(I_sh)=")
e=250-(49*0.2)
disp(e,"E_b1(in V)=V-[(I_a1)(R_a)]=")
disp("N is directly proportional to (E_b/psi)   ...
```

```
    Speed equation")
disp("[(N_0)/N1]=[(E_b0)*(psi_1)]/[(E_b1)*(psi_0)]
    i.e.  [(1000)/N1]=[(249.2)*(0.97*psi_0)]/[(240.2)
    *(psi_0)]")
n=(1000*240.2)/(249.2*0.97)
format(9)
disp(n,"Therefore, N(in rpm)=")
```

Scilab code Exa 2.28 torque

```
//exmaple2.28
clc
disp("P=6, A=2 as wave, Z=492, psi=30 mWb, I_a=40 A"
    )
disp("T=(psi*P*Z*I_a)/(2*pi*A)  Nm")
t=(40*6*492*30*10^-3)/(2*%pi*2)
format(9)
disp(t,"Therefore, T(in Nm)=")
disp("as 1N=(1/9.81)kg")
t=281.8952/9.81
format(8)
disp(t,"Therefore, T(in kgm)=")
```

Scilab code Exa 2.29 induced emf and electrical power output

```
//example2.29
clc
disp("P=4, N=1000 rpm, 80slots, psi=6*10^-2 Wb, 8
    conductors/slot")
disp("A=P=4        ... Lap connected")
z=80*8
disp(z,"Z= Slots*conductors/slot=")
e=(4*100*640*6*10^-2)/240
```

```
disp(e,"E_g(in V)=(psi*P*N*Z)/(60*A)=")
disp("As coils are lap connected, parallel paths are 4 and all conductors in each parallel path are in series, carrying a current of 50 A")
a=4*50
disp(a,"Therefore, I_a(in A)=A*current per parallel path=4*50=")
p=640*200
disp(p,"P(in W)=Electrical power output=[(E_g)*(I_a)]=")
```

Scilab code Exa 2.30 generated voltage and armature current

```
//exmaple2.30
clc
disp("The generator is shown in the fig. 2.66")
disp("I_L=50 A, V_L=500 V          ...Given")
i=500/250
disp(i,"I_sh(in A)=(V_t)/(R_sh)=")
a=2+50
disp(a,"Therefore, I_a(in A)=(I_L)+(I_sh)=2+50=")
disp("This is the armature current")
e=500+(52*0.05)+(52*0.03)+(2*1)
disp(e,"Therefore, E_g(in V)=(V_t)+[(I_a)*(R_a)]+[(I_a)*(R_se)]+Brush drop =")
disp("This is generated voltage.")
```

Scilab code Exa 2.31 induced emf and speed

```
//example2.31
clc
disp("P=8, N=400 rpm, psi=40 mWb, Z=960")
disp("a) Lap wound, A=P=8")
```

```
e=(8*400*960*40*10^-3)/(60*8)
disp(e,"E_g(in V)=(psi*P*N*Z)/(60*A)=")
disp("b) Wave connected, A=2, E_g =400 V")
disp("Therefore, (E_g)=(psi*P*N*Z)/(60*A)  i.e. 400=[(40*10^-3)*8*N*960]/(60*2)")
n=(400*60*2)/(0.04*8*960)
disp(n,"Therefore,  N(in rpm)=")
```

Scilab code Exa 2.32 back emf and gross mechanical power

```
//example2.32
clc
disp("V=250 V, (R_a)=0.3 ohm, (I_L)=20 A, (R_sh)=200 ohm")
s=250/200
disp(s,"I_sh(in A)=V/(R_sh)=")
a=20-1.25
disp(a,"I_a(in A)=(I_L)-(I_sh)=")
b=250-(18.75*0.3)
format(8)
disp(b,"E_b(in V)=V-[(I_a)(R_a)]=")
m=244.375*18.75
format(10)
disp(m,"P_m(in W)=[(E_b)*(I_a)]=")
```

Scilab code Exa 2.33 generated emf and copper and iron losses and efficiency

```
//example2.33
clc
disp("The generator is shown in the fig 2.67")
s=500/200
disp("I_sh(in A)=(V_t)/(I_sh)=")
```

```
l=(25*10^3)/500
disp(l,"I_L(in A)=(P_L)/(V_t)=")
a=50+2.5
disp(a,"Therefore,  I_a(in A)=(I_L)+(I_sh)=")
disp("Brush drop is 1V per brush hence total brush
    drop = 2V")
e=500+[52.5*(0.03+0.04)]+2
format(8)
disp(e,"a)  E_g(in V)=(V_t)+[(I_a)*(R_a)]+[(I_a)*(
    R_se)]+(V_brush)=500+[52.5*(0.03+0.04)]+2=")
a=0.03*(52.5)^2
disp(a,"b)  Armature copper loss(in W) = [(I_a)^2]*(
    R_a) =[(52.5)^2]*(0.03) =")
s=0.04*(52.5)^2
disp(s,"Series field copper loss(in W) =[(I_a)^2]*(
    R_se) =[(52.5)^2]*(0.04) =")
c=200*(2.5)^2
disp(c,"Shunt field copper loss(in W) =[(I_sh)^2]*(
    R_sh) =[(2.5)^2]*(200) =")
p=505.675*52.5
format(11)
disp(p,"P_in(in W)= (E_g)*(I_a)=")
disp("P_out = 25W")
t=26547.9375-25
format(10)
disp(t,"Therefore,  Total losses(in W) = (P_in)-(
    P_out) =")
disp("Now total losses = Copper losses + Iron losses
    ")
disp("Therefore,  1547.9375 = 82.6875 + 110.25 +
    1250 + Iron losses")
i=1547.9375-(82.6875+110.25+1250)
format(4)
disp(i,"Therefore,  Iron losses(in W)=")
n=(25000*100)/(26547.9375)
format(8)
disp(n,"%efficiency(n) =[(P_out)/(P_in)]*100 =")
```

Scilab code Exa 2.34 total armature power

```
//example2.34
clc
disp("i) As a generator")
disp("(P_out)=20 kW, (V_t)=250 V")
i=20000/250
disp(i,"I_L(in A)=(P_out)/(V_t)=")
s=250/125
disp(s,"I_sh(in A)=(V_t)/(R_sh)=")
a=80+2
disp(a,"Therefore, I_a(in A)=(I_L)+(I_sh)=")
e=250+(82*0.1)
disp(e,"E_g(in V)= (V_t)+[(I_a)*(R_a)]=")
p=258.2*82
format(7)
disp(p,"P_g(in W)=(E_g)*(I_a)=")
disp("ii) As a motor")
disp("(P_in)=20 kW, V=250 V")
i=(20000)/250
disp(i,"Therefore, I_L(in A)=(P_in)/V=")
s=250/125
disp(s,"I_sh(in A)=V/(R_sh)=")
a=80-2
disp(a,"Therefore, I_a(in A)=(I_L)-(I_sh)=")
b=250-(78*0.1)
disp(b,"Therefore, E_b(in V)=V-[(I_a)*(R_a)]=")
a=242.2*78
format(8)
disp(a,"P_a(in W)=[(E_b)*(I_a)]=")
```

Scilab code Exa 2.35 leakage coefficient

```
//example2.25
clc
disp("P=4, N=750 rpm, (E_g)=240 V, A=2 as wave, Z
    =792")
disp("(E_g)=(psi*P*N*Z)/(60*A)  i.e.  240=(psi
    *4*750*792)/(60*2)")
p=(240*60*2)/(4*750*792)
format(8)
disp(p,"Therefore, psi(in Wb)=")
disp("Lamda= Leakage coefficient = (Total flux)/(
    Useful flux)")
l=0.0145/0.01212
format(6)
disp(l,"Therefore, lamda = 0.0145/0.01212 =")
```

Scilab code Exa 2.36 no load terminal voltage and area of pole

```
//exmaple2.26
clc
disp("(P_out)=1500 kW, (V_t)=550 V, P=10, A=P as lap
    , N=150 rpm, Z=2500, (P_cu)=25 kW, B=0.9 Wb/m^2")
i=(1500*1000)/550
format(10)
disp(i,"I_L(in A)=(P_out)/(V_t)=")
disp("As R_sh is not given, neglect I_sh hence (I_a)
    =2727.2727 A")
disp("a)  P_cu = Armature copper loss = [(I_a)^2]*(
    R_a)")
disp("25*10^3 = (2727.2727)^2 * (R_a)")
a=25000/[(2727.2727)^2]
format(9)
disp(a,"Therefore, (R_a)[in ohm]=")
e=550+(2727.2727*3.3611*0.001)
disp(e,"Therefore, E_g(in V)=(V_t)+[(I_a)*(R_a)]=")
disp("This is load terminal voltage.")
```

```
disp("b) (E_g)=(psi*P*N*Z)/(60*A)  i.e.  559.1667=(
    psi*10*150*2500)/(60*10)")
p=(559.1667*60*10)/(1500*2500)
format(8)
disp(p,"Therefore, psi(in Wb)=")
disp("Now, B=(psi)/A  i.e  0.9=(0.08946)/A")
a=0.08946/0.9
disp(a,"Therefore, A(in m^2)=")
```

Chapter 3

Transformers

Scilab code Exa 3.1 primary and secondary turns and area of core

```
//example3.1
clc
disp("(B_m)=1 Wb/m^2, E1=240 V, E/turn=8 V, f=50 Hz"
   )
disp("E1=E/turn * N1          i.e.       240=8*N1")
disp("Therefore, N1=30")
disp("Therefore, N1/N2=E1/E2   i.e   30/N2=240/2400")
disp("N2=300")
disp("E1=4.44*(psi_m)*f*N1         i.e.       240=4.44*(
   psi_m)*50*30")
p=240/(4.44*50*30)
format(8)
disp(p,"Therefore, (psi_m)[in Wb]=")
a=0.03636/1
disp(a,"(B_m)=(psi_m)/a        i.e.         a(in m^2)=(
   psi_m)/(B_m)=")
```

Scilab code Exa 3.2 peak value of flux in core and secondary voltage

```
//example3.2
clc
disp("f=50 Hz, N1=480, N2=20, E1=5400 V")
disp("E1=4.44*f*(psi_m)*N1       i.e. 5400=4.44*50*(psi_m)*480")
p=5400/(4.44*50*480)
format(7)
disp(p,"Therefore, (psi_m)[in Wb]=")
disp("E1/E2=N1/N2  i.e.  E2=(N2*E1)/N1=(20*5400)/480")
e=(20*5400)/480
disp(e,"Therefore, E2(in V)=")
```

Scilab code Exa 3.3 iron loss and maximum value of flux in core

```
//example3.3
clc
disp("The given values are, (I_0)=10 A, cos(psi_0)=0.25, V1=400 V and f=50Hz")
disp("a) (I_m)=(I_0)*sin(psi_0)=Magnetising component")
p=acosd(0.25)
format(7)
disp(p,"(psi_0)[in degree]=")
i=10*sind(75.522)
disp(i,"I_m(in A)=,x")
disp("(P_i)=Iron loss = Power input on no load")
disp("= (W_0)= [(V1)*(I_0)*cos(psi_0)]= 400*10*0.25")
w=4000*0.25
disp(w,"P_i(in W)=")
disp("c) On no load, E1=V1=400 V and N1=500")
disp("E1=4.44*f*(psi_ m)*N1")
disp("Therefore, 400=4.44*50*(psi_m)*500")
i=400/(4.44*50*500)
```

```
format(9)
disp(i,"Therefore, (psi_m)[in Wb]=")
```

Scilab code Exa 3.4 primary current

```
//example3.4
clc
disp("The given values are,")
disp("(I_0)=1 A, cos(psi_0)=0.4, I2=50 A, and cos(
    psi_2)=0.8")
k=200/400
disp(k,"K=E2/E1=")
k=0.5*50
disp(k,"Therefore, I2''(in A)=K*I2=")
disp("The angle of (I2'') is to be decided from cos(
    psi_2)=0.8")
disp("Now, cos(psi_2)=0.8")
p=acosd(0.8)
format(6)
disp(p,"Therefore, (psi_2)[in degree]=")
disp("I2'' is in antiphase with I2 which lags E2 by
    36.86 degree")
disp("Consider the phasor diagram shown in the fig
    3.18. The fluz (psi) is the reference")
disp("Now cos(psi_0)=0.4")
c=acosd(0.4)
disp(c,"Therefore, psi_0(in degree)")
disp("vector(I1)=vector(I2'')+vector(I_0)")
disp("Resolve (I_0) and (I2'') into two components,
    along reference (psi) and in quadrature with (psi
    ) in phase with V1.")
x=1*sind(66.42)
format(7)
disp(x,"x component of (I_0)=(I_0)*sin(psi_0)=")
x=1*cosd(66.42)
```

```
format(4)
disp(x,"y component of (I_0)=(I_0)*(psi_0)=")
disp("Therefore, vector(I_0)=0.9165+j(0.4) A")
i=25*sind(36.86)
format(7)
disp(i,"x component of I2''(in A)=I2''*sin(psi_2)=")
i=25*0.8
disp(i,"y component of I2''(in A)=I2''*cos(psi_2)=")
disp("Thus the two component of I1 are as shown in the fig 3.18(c)")
io=sqrt((15.9165^2)+(20.4^2))
disp(io,"I1(in A)=sqrt[((15.9165)^2)+(20.4)^2]=")
disp("This is the primary current magnitude.")
disp("while tan(phi_1)=15.9165/20.4")
t=atand(15.9165/20.4)
disp(t,"Therefore, (psi_1)[in degree]=")
disp("Hence the primary power factor is,")
i=cosd(37.96)
disp(i,"cos(psi_1)[lagging]=cos(37.96)=")
disp("Key point: Remember that (psi_1) is angle between V1 and I1 and as V1 is vertical, (psi_1) is measured with respect V1. So do not convert rectangular to polar as it goes angle with respect to x-axis and we want it with respect to y-axis.")
```

Scilab code Exa 3.5 equivalent resistance

```
//example3.5
clc
disp("The given values are, R1=2.5 ohm, R2=0.01 ohm")
k=400/6600
disp(k,"K=400/6600=")
disp("While finding eqivalent resistance referred to
```

```
    primary, transfer R2 to primary as R2'',")
r=0.01/((0.0606)^2)
disp(r,"R2''(in ohm)=R2/K^2=")
r=2.5+2.7225
format(7)
disp(r,"Therefore, (R_1e)[in ohm]=R1+R2''=")
disp("It can be observed that primary is high
   voltage hence high resistance side hence while
   transferring R2 from low  voltage to R2'' on high
    voltage, its value increses.")
disp("To find total equivalent resistance referred
   to secondary, first calculate R1'',")
r=2.5*(0.0606)^2
format(8)
disp(r,"R1''(in ohm)=(K^2)*R1=(0.0606^2)*2.5=")
r=0.01+0.00918
disp(r,"(R_2e)(in ohm)=R2*R1''=0.01*0.00918=")
```

Scilab code Exa 3.6 total resistance and equivalent reactance and impedance

```
//example3.6
clc
disp("R1=1 ohm, R2=2 ohm, X1=3 ohm, X2=5 ohm")
k=110/220
disp(k,"K=V2/V1=")
r=1+(2/((0.5)^2))
disp(r,"Therefore, (R_1e)[in ohm]=R1+R2''=R1+(R2/K
   ^2)=")
x=3+(5/((0.5)^2))
disp(x,"Therefore, (X_1e)[in ohm]=X1+X2=X1+(X2/K^2)=
   ")
z=sqrt((9^2)+(23^2))
format(8)
disp(z,"Therefore, (Z_1e)[in ohm]=sqrt((R_1e^2)+(
   X_1e^2))=")
```

```
r=9*(0.5^2)
disp(r,"Therefore, (R_2e)[in ohm]=(K^2)*(R_1e)=")
x=(0.5^2)*23
disp(x,"and, (X_2e)[in ohm]=(K^2)*(X_1e)=")
z=(0.5^2)*24.6981
format(7)
disp(z,"Therefore, (Z_2e)[in ohm]=sqrt((R_2e^2)+(
    X_2e^2))=(K^2)*(Z_1e)=")
```

Scilab code Exa 3.7 regulation and secondary terminal voltage

```
//example3.7
clc
disp("The given values are, R1=0.2 ohm, R2=0.05 ohm,
     X1=0.75 ohm, X2=0.2 ohm, cos(psi)=0.8 leading")
k=125/250
disp(k,"E2/E1=")
i=(5*10^3)/125
disp(i,"(I2)(F.L)[in A]=(kVA)/V2=")
r=0.05+((0.5^2)*0.2)
disp(r,"R_2e(in ohm)=R2+(K^2)*R1=")
x=0.2+((0.5^2)*0.75)
format(7)
disp(x,"X_2e(in ohm)=X2+(K^2)*X1=")
disp("i) Regulation on full load, cos(psi)=0.8
    leading")
disp("sin(psi)=0.6")
disp("Therefore, %R=[(I2)*(R_2e)*cos(psi)-(I2)*(X_2e
    )*sin(psi)]/E2 * 100,           ..I2=I2(FL)=40 A")
disp(" = (40*0.1*0.8-40*0.3875*0.6)/125 * 100")
r=((40*0.1*0.8)-(40*0.3875*0.6))/1.25
format(5)
disp(r," = ")
disp("ii) On full load, 0.8 p.f. leading the total
    voltage drop is,")
```

```
disp("Voltage drop(in V) = I2(FL)[(R_2e)cos(psi)-(X_2e)sin(psi)]")
v=40*((0.1*0.8)-(0.3875*0.6))
format(4)
disp(v," = ")
disp("Therefore, E2-V2= -6.1  i.e.  125-V2= -6.1")
v=125+6.1
format(6)
disp(v,"Therefore, V2(in V)= Secondary terminal voltage = 125+ 6.1 =")
```

Scilab code Exa 3.8 total copper loss and efficiency

```
//example3.8
clc
disp("The given values are, V1=200 V, V2=400 V, S=4 kVA, (R_1e)=0.15 ohm, P1= 60 W")
k=4/2
disp(k,"K=400/200=")
r=(2^2)*0.15
disp(r,"Therefore, (R_2e)[in ohm]=(K^2)(R_1e)=")
i=4000/400
disp(i,"I2(FL)[in A]=(kVA)/V2=")
disp("i) Total copper losses on full load,")
p=(10^2)*0.6
disp(p,"(P_cu)(FL)[in W]=[I2(FL)]^2 * (R_2e) =(10^2)*0.6 =")
disp("ii) cos(psi)=0.9 lagging and full load")
disp("Therefore, %n = [(VA rating cos(psi))/(VA rating cos(psi)+(P_i)+(P_cu)FL)]*100")
n=(4*0.9*10^5)/((4*0.9*10^3)+60+60)
format(6)
disp(n,"Therefore, n(% efficiency)=(4*0.9*10^3)/((4*0.9*10^3)+60+60) * 100 =")
disp("iii) cos(psi)=0.8 leading, half load")
```

```
disp("As half load , n=0.5")
p=(0.5^2)*60
disp(p,"(P_cu)(HL)[in W]=(n^2)*[(P_cu)(FL)]=(10.5^2)
    *60 =")
disp("Therefore , %n = [n*(VA rating cos(psi))/(n*VA
    rating cos(psi)+(P_i)+(P_cu)FL)]*100")
n=(4*0.5*0.8*10^5)/((4*0.8*0.5*10^3)+60+15)
disp(n," = ")
```

Scilab code Exa 3.9 maximum efficiency

```
//exmaple3.9
clc
disp("(P_i)=1.2 kW, (P_cu)(FL)=1.5 kW, kVA=100")
n=100*sqrt(1.2/1.5)
format(8)
disp(n,"i) kVA for (n_max)=kVA*sqrt((P_i)/(P_cu))=")
disp("ii) For n_max, (P_cu)=(P_i)=-1.2 kW")
disp("Therefore , %(n_max)=[(kVA for n_max)*cos(psi)
    ]/[(kVA for n_max)*cos(psi)+2(P_i)]*100         ..
    cos(psi)=1")
n=(89.4427*10^5)/((89.4427*10^3)+(2*1.2*10^3))
format(7)
disp(n,"%eta_max(in percentage) = ")
```

Scilab code Exa 3.10 efficiency and unity power factor

```
//example3.10
clc
disp("20 kVA, N_max=0.98 at 15 kVA and cos(psi)=1, (
    P_i)=350 W")
disp("Load at n_max=kVA*sqrt(P_i/P_cu)")
disp("Therefore , 15=20*sqrt(350/P_cu)     i.e. ")
```

```
p=350/((15/20)^2)
format(8)
disp(p,"P_cu(FL)[in W]=")
disp("i) %n at cos(psi)=0.8 lag, full load")
disp("%n(FL)= [VA cos(psi) *100]/[(VA cos(psi))+(
    P_cu(FL))+(P_i)]=[20*10^3*(0.8)
    *100]/[(20*10^3*(0.8))+(622.222)+(350)]")
n=[20000*(0.8)*100]/[(20000*(0.8))+(622.222)+(350)]
format(7)
disp(n,"= ")
disp("ii) %n at cos(psi)=1 , full load")
n=(20000*100)/(20000+622.222+350)
format(8)
disp(n,"%n(FL)=(20*10^3*1*100)/((20*10^3*1)
    +622.222+350)=")
```

Scilab code Exa 3.11 copper loss and full and half load efficiency and regulation

```
//Example 3.11
clc
disp("From O.C. test we can write,")
disp("  Wo = P1 = 50 W = Iron loss")
disp("From S.C. test we can find the parameters of
    eqivalent circuit. Now S.C. test is conducted on
    H.V. side i.e. meters are on H.V. side which is
    tranformer secondary. Hence parameters from S.C.
    test results will be refered to secondary.")
disp("V_sc = 15 V,  I_sc = 30 A,  W_sc = 100 W")
r2e=10/(30^2)
format(6)
disp(r2e,"Therefore,  R_2e (in ohm)= W_sc / (I_sc)^2
    =")
z1e=15/30
format(4)
```

```
disp(z1e,"  Z_1e(in ohm) = V_sc / I_sc =")
x2e=sqrt((0.5^2)-(0.111^2))
format(7)
disp(x2e,"Therefore,  X_2e(in ohm) = sqrt(Z_2e^2 -
    R_2e^2) =")
disp("(i) Copper loss on full load")
i2=(10^4)/250
format(3)
disp(i2,"(I2)F.L (in A)= VA rating / V2 =")
disp("In short circuit test, I_sc = 30 A and not
    equal to full load value 40 A")
disp("Hence W_sc does not give copper loss on full
    load.")
disp("Therefore,  W_sc = P_cu at 30 A = 100 W")
disp("Now  P_cu  directly proprotional to  I^2")
disp("Therefore,  P_cu at 30 A / P_cu at 40 A =
    (30/40)^2")
disp("Therefore,  100 / P_cu at 40 A = 900/1600")
pcu=(1600*100)/900
format(7)
disp(pcu,"Therefore,  P_cu at 40 A (in W)= ")
disp("Therefore,  (P_cu)F.L = 177.78 W")
disp("(ii) Full load eta,  cos(phi2) = 0.8")
disp("%eta on full load = V2(I2)F.L.*cos(phi2)*100 /
     V2(I2)F.L.*cos(phi2)+Pi+(P_cu)F.L")
n=(250*40*0.8*100)/((250*40*0.8)+50+177.78)
format(6)
disp(n,"= (250*40*0.8*100)/((250*40*0.8)+50+177.78)
    = ")
disp("iii) Half load eta, cos(phi_2)=0.8")
disp("n=0.5 as half load,  (I2)[H.L.]=40/2 =20 A")
disp("Therefore, %eta on full load = V2(I2)H.L.*cos(
    phi2)*100 / V2(I2)H.L.*cos(phi2)+Pi+(n^2)(P_cu)F.
    L")
disp("= n*(VA rating)*cos(phi2)*100 / n*(VA rating)*
    cos(phi2)+Pi+(P_cu)F.L")
disp("= 0.5*10*10^3*0.8*100/(0.5*10*10^3*0.8)
    +50+(0.5^2)*177.78")
```

```
n=(0.5*10*1000*0.8*100)/((0.5*0.8*10^4)+50+(100.78*(0.5^2)))
disp(n," = ")
disp("iv) Regulation at full load, cos(phi)=0.9 leading")
disp("%R = (I2)F.L.*(R_2e)*cos(phi)-(I2)F.L.*(X_2e)*sin(phi)*100/V2")
r=(((40*0.111*0.9)-(40*0.4875*0.4358))*100)/250
format(7)
disp(r," = (40*0.111*0.9)-(40*0.4875*0.4358)*100/250 =")
```

Scilab code Exa 3.12 voltage and power factor

```
//example3.12
clc
disp("R1=0.9 ohm, R2=0.03 ohm, X1=5 ohm, X2=0.13 ohm")
disp("K=N2/N1=1/6 as N1:N2 is 6:1")
r=0.03+(0.9*(1/6)^2)
format(6)
disp(r,"Therefore, (R_2e)[in ohm]=R2+R1''=R2+(K^2)*R1=0.03+(1/6)^2*0.9=")
x=0.13+(5*(1/6)^2)
format(8)
disp(x,"(X_2e)[in ohm]=X2+X1''=X2+(K^2)*X1=0.13+(5*(1/6)^2)=")
disp("I_sc = 200 A")
disp("(Z_2e)=(V_sc)/(I_sc)   i.e.   sqrt((R_2e^2)+(X_2e^2))=(V_sc)/200")
v=200*0.27444
disp(v,"V_sc(in V)=200*0.27444=")
v=54.8895*6
disp(v,"i) V1(in V)=(V_sc)/K=54.8895/(1/6)=")
disp("(W_sc)=(V_sc)*(I_sc)*cos(phi_sc)     and     (
```

```
    W_sc)=(I_sc^2)*(R_2e)")
disp("Therefore, (200^2)*0.055 = 54.8895*200*cos(
    phi_sc)")
s=((0.055*200)/(54.8895))
format(4)
disp(s,"Therefore, cos(phi_sc)[lagging]=")
```

Scilab code Exa 3.13 all day efficiency

```
//exmaple3.13
clc
disp("Given values are, P_i=2.5 kW, (P_cu)F.L. = 3.5
    kW, 400 kVA")
disp("Iron losses are constant for 24 hours. So
    energy spent due to iron lossses for 24 hours is,
    ")
p=2.5*24
disp(p,"P_i(in kWh)=2.5*24 hours=")
disp("Total energy output in a day from given load
    cycle is,")
e=(300*6)+(200*10)+(100*4)
disp(e,"Energy output (in kWh)= (300*6 hours)
    +(200*10 hours)+(100*4 hours)=")
disp("To calculate energy spent due to copper loass,
    ")
disp("i)Load 1 of 300 kW at cos(phi)=0.8")
k=300/0.8
disp(k,"Therefore, kVA supplied = kW/cos(phi)
    =300/0.8=")
n=375/400
format(7)
disp(n,"Therefore, n=(load kVA)/(kVA rating)
    =375/400=")
disp("Copper losses are proportional to square of
    kVA ratio i.e. n^2")
```

```
l=3.5*(0.9375)^2
format(6)
disp(l,"Therefore, Load 1 P_cu = n^2*(P_cu)F.L.=(0.9375)^2*3.5=")
e=3.076*6
format(7)
disp(e,"Energy spent(in kWh)=3.076*6 hours=")
disp("ii) Load 2 of 200 kW at cos(phi)=0.7")
k=200/0.7
format(9)
disp(k,"Therefore, kVA supplied=(kW)/cos(phi)=200/0.7=")
n=285.7142/400
format(7)
disp(n,"n=(Load kVA)/(kVA rating)=")
p=3.5*(0.7142^2)
disp(p,"Therefore, Load 2 P_cu(in kW)= n^2*(P_cu)F.L.= (0.7142^2)*3.5=")
p=1.7857*10
disp(p,"Therefore, Energy spent(in kWh)= 1.7857*10 =")
disp("iii) Load 3 of 100 kW at cos(phi)=0.9")
k=100/0.9
format(8)
disp(k,"Therefore, kVA supplied=kW/cos(phi)=100/0.9=")
n=111.111/400
format(7)
disp(n,"Therefore, n=111.111/400=")
p=3.5*(0.2778^2)
disp(p,"Therefore, Load 3 P_cu(in kW)= n^2*(P_cu)F.L.=(0.2778^2)*3.5= ")
e=0.2701*4
disp(e,"Therefore, Energy spent(in kWh)=0.2701*4=")
disp("iv) No load hence negligible copper losses.")
t=60+18.457+17.857+1.0804
format(8)
disp(t,"Therefore, Total energy spent = Energy spent
```

```
    due to [Iron losses + Total copper loss]=
    60+18.457+17.857+1.0804 = ")
disp("and Total output = 4200 kWh")
disp("Therefore, All day eta= (Total output for 24
    hours)/(Total output for 24 hours+Total energy
    spent for 24 hours)")
n=420000/(4200+97.3944)
format(6)
disp(n,"= 4200*100/(4200+97.3944) = ")
```

Scilab code Exa 3.14 copper loss and efficiency

```
//example3.14
clc
disp("eta % =98% ,S= 200 kVA, cos(phi)=0.8, Iron
    loss=200 W")
disp("Therefore, eta % = (200*10^3 *0.8*100)
    /(200*10^3 *0.8+2000+copper loss)")
disp("0.98[200*10^3 *0.8+2000+copper loss]=200*10^3
    *0.8")
c=((200*800)/0.98)-((200*800)-2000)
format(9)
disp(c,"i)Copper loss at full load(in watt)=")
disp("ii)Half load copper loss(in watt) = (n^2)*(
    W_cu)full load        where n=0.5 as half load")
x=(0.5^2)*1265.306
format(8)
disp(x,"=(0.5^2)*1265.306 =")
disp("Efficiency at half load = (100*10^3 *0.8*100)
    /(100*10^-3 *0.8+2000+316.326)")
n=(100*800*100)/((0.8*100000)+2000+316.326)
format(7)
disp(n,"eta % = ")
```

Scilab code Exa 3.15 iron and copper loss

```
//example3.15
clc
x=250*800
disp(x,"a)The output power at full load(in watt)=")
disp("THe input power at full load =(200*10^3)
    /0.98135")
disp("The total loss = Input-Output")
t=((200*10^3)/0.98135)-200000
format(8)
disp(t,"= ")
disp("Therefore, P_i + P_c = 3800.88          (i)")
disp("where      P_i= Iron loss   ,P_c = Full load
    copper loss")
p=125*800
disp(p,"The power output at half load=125*10^3 *0.8=
    ")
disp("The power input at half load = (100*10^3)
    /0.97751")
x=((100*10^3)/0.9775)
disp(x,"Total loss = (100*10^3)/0.9775 - 100*10^3 ="
    )
disp("(P_i)+ (0.5^2)*(P_c) = 2300.74")
disp("(P_i)+ (0.25)*(P_c) = 2300.74           (ii)")
disp("From equations (i) and (ii),")
disp("0.75*(P_i)=3800.88-2300.74")
p=(3800.88-2300.74)/0.75
disp(p,"Therefore, P_i(in watt)=")
z=3800.88-2000.18
disp(z,"P_c(in watt)=")
```

Scilab code Exa 3.16 regulation

```
//example3.16
clc
disp("100 kVA, 1000 V/ 10000 V, P_i=1200 W, cos(phi)=0.8, P_cu on I2 = 6A is 500W, X_2e=10 ohm")
disp("For eta_max, P_cu=(P_i)=1200 W")
i=(100*10^3)/10000
disp(i,"(I_2)F.L.[in A] = VA rating/V2 = (100*10^3)/10000 = ")
disp("Therefore, P_cu on any load/(P_cu)F.L. = [I2 load/I2 F.L]^2    ...As (P_cu) directly proportional I^2")
disp("Therefore, 500/(P_cu)F.L. = (6/10)^2")
p=500*(10/6)^2
format(8)
disp(p,"Therefore, (P_cu)F.L.[in W] = ")
k=100*sqrt(1200/1388.88)
disp(k,"kVA at eta_max = (kVA rating)*sqrt(P_i/(P_cu)F.L) = 100*sqrt(1200/1388.88) =")
disp("Therefore, % eta_max = (kVA for n_max cos(phi)*100)/(kVA for n_max cos(phi)+2P_i)")
n=(92951.8*0.8*100)/((92951.8*0.8)+(2*1200))
disp(n,"= (92951.8*0.8*100)/((92951.8*0.8)+(2*1200)) = ")
i=10*sqrt(1200/1388.88)
format(7)
disp(i,"(I_2m) at eta_max [in A]= (I_2)F.L. * sqrt(P_i/(P_cu)F.L.) = ")
disp("Therefore, (P_cu) at eta_max = P_i = (I_2m)^2 * R_2e")
disp("Therefore, 1200 = (9.2951^2)*R_2e")
r=1200/(9.2951^2)
disp(r,"Therefore, R_2e[in ohm] = ")
disp("% R = (I_2m)[R_2e cos(phi)+(X_2e)sin(phi)*100]/V2")
po=(9.2951*((13.889*0.8)+(10*10*0.6)))/100
format(5)
```

```
disp(po,"= (9.2951*((13.889*0.8)+(10*10*0.6))*100)
   /10000 = ") //answer in text book is wrong
```

Scilab code Exa 3.17 efficiencies

```
//exmaple3.17
clc
disp("5 kVA, 2300/230 V, P_i=40 W, (P_cu)F.L. =112 W
   , cos(phi)=0.8")
disp("Sr.     kVA        n=Fraction of full load
             New P_cu=          %eta=n[Total VA]cos(phi)/
   n[Total VA]cos(phi)+P_i+New P_cu *100")
disp("No.    output      =Actual kVA/total kVA          n
   ^2 P_cu(F.L.) ")
disp("1      1.25          0.25
                                   7
   95.51%")
disp("2       2.5          0.5
                                    28
                     96.711%")
disp("3      3.75          0.75
                                   63
   96.668%")
disp("4        5            1
                                     112
                    96.339%")
disp("5      6.25          1.25
                                   175
   95.877%")
disp("6      7.5           1.5
                                    252
                    95.359%")
disp("")
disp("The efficiency against kVA output curve is
   shown in the fig. 3.28")
```

Scilab code Exa 3.18 load impedance and maximum flux

```
//example3.18
clc
disp("50 kVA, V1=2400 V, V2=240 V, N2=23")
k=1/10
disp("K=N2/N1=1/10=")
i=(50*10^3)/240
format(8)
disp(i,"(I_2)F.L. = VA/V2 = (50*10^3)/240 =")
r=240/208.333
disp(r,"R_L (in ohm)=V2/(I_2)F.L. = 240/208.333= ")
disp("From the e.m.f equation,")
disp("240 = 4.44*50*phi*23")
p=240/(4.44*50*23)
format(6)
disp(p,"Therefore, phi_m(in Wb)=")
```

Scilab code Exa 3.19 number of primary and secondary turns

```
//example3.19
clc
disp("E1=2300 V, E2=230 V, f=50 Hz, B_m=1.1 Wb/m^2 ,
    A=0.05 m^2")
disp("B_m=(phi_m)/A        i.e        1.1=(phi_m)/0.05")
p=1.1*0.05
format(6)
disp(p,"Therefore, (phi_m)[in Wb]=")
disp("E1=4.44(phi_m)*f*N1    i.e.
    2300=4.44*0.055*50*N1")
n=2300/(4.44*0.055*50)
```

```
format(7)
disp(n,"Therefore,N1 = ")
disp("E2=4.44(phi_m)*f*N2    i.e.
   230=4.44*0.055*50*N2")
n=230/(4.44*0.055*50)
disp(n,"Therefore, N2 = ")
```

Scilab code Exa 3.20 maximum efficiency

```
//example3.20
clc
disp("150 kVA, P_i=1.4 kW, P_cu(FL)=1.6 kW")
k=150*sqrt(1.4/1.6)
format(9)
disp(k,"a) kVA for eta_max = kVA*sqrt(P_i/P_cu(FL))=
   ")
disp("For maximum efficieny, P_cu=P_i=1.4kW and cos(
   phi)=1")
disp("Therefore, %eta_max=(VA for eta_max *cos(phi))
   /(VA for eta_max*cos(phi)+2P_i *100")
n=(140.3121*1000*100)/(140312.1+(2*1.4*1000))
format(7)
disp(n,"= (140.3121*1000*100)/(140312.1+(2*1.4*1000)
   ) = ")
disp("b) At half load, n=0.5, cos(phi)=0.8")
disp("Therefore, %eta_HL = (n*VA*cos(phi)*100)/(n*VA
   *cos(phi)+P_i+[n^2 *P_cu(FL)])")
n=(0.5*150*1000*0.8*100)/((0.5*150*1000*0.8)
   +(1.4*10^3)+(1.6*1000*0.5^2))
disp(n,"= (0.5*150*1000*0.8*100)/((0.5*150*1000*0.8)
   +(1.4*10^3)+(1.6*1000*0.5^2)) = ")
```

Scilab code Exa 3.21 area of core

```
//exmaple3.21
clc
disp("E1=1900 V, E2=240 V, f=50Hz, B_m=1.5 Wb/m^2, emf/turn = E1/N1 = E2/N2")
disp("Therefore, 1.5=1900/N1=240/N2")
n=1900/1.5
format(8)
disp(n,"Therefore, N1=")
n=240/1.5
disp(n,"and, N2=")
disp("E1=4.44*(phi_m)*f*N1   i.e.   1900=4.44(phi_m)*50*1267")
p=1900/(4.44*50*1267)
format(9)
disp(p,"Therefore, (phi_m)[in Wb]=")
disp("(B_m)=(phi_m)/A   i.e.   1.5=(6.7567*10^-3)/A")
a=(6.7567*10^-3)/1.5
format(10)
disp(a,"Therefore, A(in m^2)=")
i=10000/240
format(7)
disp(i,"I2(in A)=Output VA/E2 = (10*10^3)/240 = ")
```

Scilab code Exa 3.22 efficiency

```
//example3.22
clc
disp("%eta_FL = 96%, cos(phi)=0.8, %eta_HL =97.2%, cos(phi)=1")
disp("%eta_FL=(VA *cos(phi))/(VA *cos(phi)+P_i+P_cu(FL))*100      i.e.   0.96=((259*10^3)*0.8)/((250*10^3)*0.8+P_i+P_cu(FL))")
disp("Therefore, P_i+P_cu(FL)=8333.333          ...(1)")
disp("%eta_HL=(n*VA*cos(phi))/(n*VA*cos(phi)+P_i+(n^2)*P_cu(FL)) *100          ...n=0.5 for half load")
```

```
disp("Therefore, 97.2=(0.5*250*(10^3)*1)/(0.5*250*(10^3)*1+P_i+(0.5^2)*P_cu(FL)) *100")
disp("Therefore, P_i+(0.5^2)*P_cu(FL)=3600.823 ..(2)")
disp("Solving equations (1) and (2),")
disp("3600.823-(0.5^2)*P_cu(FL)+P_cu(FL)=8333.333")
disp("0.75*(P_cu)FL=8333.333-3600.823")
p=(8333.333-3600.823)/0.75
format(9)
disp(p,"P_cu(FL)[in W]=")
p=8333.333-6310.013
format(9)
disp(p,"P_i(in W)=")
disp("At 75% of full load, n=0.75 and cos(phi)=0.8")
disp("Therefore, %eta=(n*VA*cos(phi))/(n*VA*cos(phi)+P_i+(n^2)*P_cu(FL)) *100")
disp("=(0.75*2508(10^3)*0.8)/(0.75*250*(10^3)*0.8+2023.319+(0.75^2)*6310.013)) *100")
n=(0.75*250*(10^3)*0.8*100)/((0.75*250*(10^3)*0.8)+2023.319+((0.75^2)*6310.013))
format(8)
disp(n,"= ")
```

Scilab code Exa 3.23 turns ratio and magnetizing and working component and iron loss

```
//example3.23
clc
disp("V_0=220 V, I_0=0.5 A, W_0=30 W, R1=0.6ohm")
disp("W_0=(V_0)*(I_0)*cos(phi_0)     i.e.     cos(phi_0)=30/(220*0.5)")
c=30/(220*0.5)
format(8)
disp(c,"Therefore, cos(phi_0)=")
p=acosh(0.27272)
```

```
disp(p,"i.e.  (phi_0)[in degree]=")
k=110/220
disp(k,"a) K=Turns ratio=Secondary voltage/Primary voltage=110/220=")
i=0.5*0.27272
disp(i,"b) I_m(in A)=(I_0)*cos(phi_0)=0.5*0.27272=")
i=0.5*sind(74.1733)
format(6)
disp(i,"I_c(in A)=(I_0)*sin(phi_0)=0.5*sin(74.1733)=")
p=30-((0.5^2)*0.6)
disp(p,"P_i(in W)=Iron loss=(W_0)-No load copper loss=(W_0)-(I_0^2)*R1=")
```

Scilab code Exa 3.24 efficiency and load

```
//example3.24
clc
disp("50 kVA,  P_i=500 W,  P_cu(FL)=600 W")
disp("a)     cos(phi)=1,  Full load")
n=(50*(10^3)*1*100)/((50*10^3)+500+600)
format(7)
disp("Therefore,  %eta=(VA*cos(phi))/(VA*cos(phi)+P_i+P_cu(FL))  *100=(50*(10^3)*1*100)/((50*10^3)*1+500+600)= ")
k=50*sqrt(500/600)
format(8)
disp(k,"b) kVA at eta_max= kVA*sqrt(P_i/P_cu(FL))=50*sqrt(500/600)= ")
i=(50*10^3)/400
disp(i,"I_2(FL)[in A]=VA/V2=(50*10^3)/400=")
i=125*sqrt(500/600)
format(9)
disp(i,"I_2m(in A)=I_2(FL)*sqrt(P_i/P_cu(FL))=")
```

Scilab code Exa 3.25 flux density and transformation ratio and voltage induced and

```
//example3.25
clc
disp("N1=400, N2=1000, A=60 cm^2, f=50 Hz, E1=520 V"
    )
disp("a) E1=4.44*(phi_m)*f*N1    i.e.     520=4.44*(
    phi_m)*50*400")
p=520/(4.44*50*400)
format(9)
disp(p,"Therefore, (phi_m)[in Wb]= ")
b=(5.8558*10^-3)/(60*10^-4)
format(7)
disp(b,"Therefore, (B_m)[in Wb/m^2]=(phi_m)/A= ")
k=1000/400
disp(k,"b) K=N2/N1=1000/400= ")
disp("c) N2/N1=E2/E1    i.e.     1000/400=E2/520")
e=(1000*520)/400
disp(e,"Therefore, E2(in V)=")
e=520/400
disp(e,"d) E1/turns=E1/N1=520/400=")
e=1300/1000
disp(e,"E2/turns=E2/N2=1300/1000=")
```

Scilab code Exa 3.26 voltage regulation and efficiency

```
//example3.26
clc
disp("From O.C. test, P_i=Iron losses=75 W")
disp("From S.C. test, V_sc=9.5 V, I_sc=20A, W_sc=110
    W")
```

```
disp("The meters are on H.V. side i.e. primary hence,")
z=9.5/20
format(6)
disp(z,"Z_1e(in ohm)=(V_sc)/(I_sc)=")
r=110/(20^2)
disp(r,"R_1e(in ohm)=(W_sc)/(I_sc)^2=")
x=sqrt((0.475^2)-(0.275^2))
format(7)
disp(x,"Therefore, (X_1e)[in ohm]=sqrt((Z_1e^2)-(R_1e^2))=")
i=(8*10^3)/400
disp(i,"I1(FL)[in A]=I_sc=VA/V1=(8*10^3)/400=")
disp("Therefore, (W_sc)[in W]=(P_cu)(FL)=110 W ...Copper losses on full load")
disp("For   cos(phi)=0.8,  sin(phi)=0.6")
disp("Therefore, %R = I1(FL)*100*[R_1e*cos(phi)+X_1e*sin(phi)]")
r=(20*100*((0.275*0.8)+(0.3873*0.6)))/400
disp(r," = 20*100*[0.275*0.8+0.3873*0.6]/400= ")
disp("%eta_FL= VA*cos(phi)/(VA*cos(phi)+P_i+P_cu(FL))*100")
n=((8*10^3)*0.8*100)/((8*0.8*10^3)+75+110)
format(6)
disp(n,"= ((8*10^3)*0.8*100)/((8*0.8*10^3)+75+110)=")
```

Scilab code Exa 3.27 all day efficiency

```
//example3.27
clc
disp("Load distribution in hours is as give in the table.")
disp("P_i=Iron loss=1.6 kW, P_cu(FL)=3.02 kW")
disp("As iron losses are constant for 24 hours,
```

```
   energy spent due to iron losses,")
p=1.6*24
disp(p,"P_i(in kWh)=1.6*24= ")
e=(6*160)+(4*80)+(1*0)
disp(e,"Energy Output(in kWh)= (6*160)+(4*80)+(1*0)
   = ")
disp("To calulate energy spent due to copper loss:")
disp("Load 1: 160 kW, cos(phi)=0.8")
k=160/0.8
disp(k,"Therefore, kVA=kW/cos(phi)=160/0.8=")
e=3.02*6
disp(e,"Therefore, E1(in kWh)=P_cu(FL)*hours=3.02*6=
   ")
disp("Load 2: 80kW, cos(phi)=1")
k=80/1
disp(k,"Therefore, kVA=kW/cos(phi)=80/1=")
n=80/200
disp(n,"Therefore, n=Fraction of load=(load kVA)/(
   kVA rating)=80/200=")
p=(0.4^2)*3.02
format(7)
disp(p,"Therefore, P_cu(in kW)=(n^2)*P_cu(FL)
   =(0.4^2)*3.02=")
e=0.4832*4
disp(e,"Therefore, E2(in kWh)=P_cu*hours=0.4832*4=")
t=38.4+18.12+1.9328
format(8)
disp(t,"Total energy spent(in kWh)=P_i+E1+E2
   =38.4+18.12+1.9328= ")
n=(1280*100)/(1280+58.4528)
disp(n,"Therefore, All day eta=(total energy output
   in 24 hours*100)/(total energy output for 24
   hours+total energy spent)=(1280*100)
   /(1280+58.4528)=")
```

Chapter 4

Alternators

Scilab code Exa 4.1 calculate distribution factor

```
//Example 4.1
clc
n=120/8
format(3)
disp(n,"n = slots/pole =")
m=15/3
disp(m,"m = slots/pole/phase = n/3 =")
beta=180/15
disp(beta,"beta(in degree) = 180/n =")
kd=(sind(30)/(5*sind(6)))
format(6)
disp(kd,"Therefore, K_d = sin(m*beta/2) / m*sin(
    beta/2) =")
```

Scilab code Exa 4.2 calculate coil factor

```
//Example 4.2
clc
```

```
n=36/4
format(3)
disp(n,"n = slots/pole =")
beta=180/9
disp(beta,"beta(in degree) = 180/n =")
disp("Now coil is shorted by 1 slot i.e. by 20 to
   full pitch distance.")
disp("Therefore,  alpha = Angle of short pitch = 20"
   )
kc=cosd(10)
format(7)
disp(kc,"Therefore,  K_c = cos(alpha/2) =")
```

Scilab code Exa 4.3 find induced emf

```
//Example 4.3
clc
disp("Ns = 250 r.p.m,  f = 50 Hz")
disp("Ns = 120f / P")
p=(120*50)/250
disp(p,"Therefore,  P = ")
n=216/24
format(3)
disp(n,"n = slots/pole =")
m=9/3
disp(m,"m = n/3 =")
beta=180/9
disp(beta,"beta(in degree) = 180/n =")
kd=(sind(30)/(3*sind(10)))
format(6)
disp(kd,"Therefore,  K_d = sin(m*beta/2) / m*sin(
   beta/2) =")
disp("K_c = 1 as full pitch coils.")
z=216*5
format(8)
```

```
disp(z,"Total number of conductors Z = ")
zph=1080/3
disp(zph,"Therefore,  Z_ph = Z/3 =")
tph=360/2
disp(tph,"Therefore,  T_ph = Z_ph/2 =                  ...
    2 conductors constitute 1 turn")
eph=4.44*0.9597*30*50*180*10^-3
format(8)
disp(eph,"E_ph(in V) = 4.44*Kc*Kd*f*phi*T_ph =")
el=sqrt(3)*1150.48
disp(el,"E_line(in V) = sqrt(3)*E_ph =                ...
   star connection")
```

Scilab code Exa 4.4 find poles and flux

```
//Example 4.4
clc
disp("E_line = 4000 V,  f = 50 Hz,  N_s = 750 r.p.m,
     m = 3,  K_c = 1")
eph=4000/sqrt(3)
format(9)
disp(eph,"E_ph(in V) = E_line/sqrt(3) =")
p=(120*50)/750
disp("(i) N_s = 120f / P")
disp(p,"Therefore,  P =")
disp("(ii) n = slots/pole = m*3 = 9")
b=180/9
disp(b,"beta = 180/n =")
kd=sind(30)/(3*sind(10))
format(7)
disp(kd,"Therefore,  K_d = sin(m*beta/2) / m*sin(
   beta/2) =")
ns=9*8
disp(ns,"Number of slots = n * P =")
z=72*12
```

```
disp(z,"Z = Slots * counductors/slots =")
zp=864/3
disp(zp,"Therefore, Z_ph = Z/3 =")
tp=288/2
disp(tp,"Therefore, T_ph = Z_ph/2 =")
phi=2309.401/(4.44*0.9598*50*144)
format(8)
disp("Therefore, E_ph = 4.44*K_c*K_d*phi*f*T_ph")
disp(phi,"Therefore, phi(in Wb) = ... flux per pole")
```

Scilab code Exa 4.5 calculate emf

```
//Example 4.5
clc
disp("P = 100 kW, cos(phi) = 0.8 lagging")
disp("V_L = 11 kV, R_a = 0.4 ohm, X_s = 3 ohm")
disp("For three phase load, P = sqrt(3)*V_L*I_L*cos(phi)")
il=(1000*10^3)/(sqrt(3)*11*0.8*10^3)
format(5)
disp(il,"Therefore, I_L(in A) =")
disp("Now I_L = I_a as for star connected alternator I_L = I_ph")
disp("Therefore, I_aph = 65.6 A ... full load per phase armature current")
disp("For lagging p.f. loads,")
disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)+I_a*X_s)^2")
vp=(11*10^3)/sqrt(3)
format(9)
disp(vp,"Now V_ph = V_L / sqrt(3) = ... as star connected")
eph=(((6350.853*0.8)+(65.6*0.4))^2)+(((6350.853*0.6)+(65.6*3))^2)
```

```
p=sqrt(eph)
format(8)
disp(p,"Therefore,  E_ph(in V) = ")
el=(sqrt(3)*6491.47)*10^-3
format(6)
disp(el,"Therefore,  E_line(in kV) =")
regu=((6491.47-6350.853)/6350.853)*100
disp(regu,"and  %Regulation(in percentage) = (E_ph-
   V_ph / V_ph)*100 =")
disp("For lagging p.f. loads, regulation is always
   positive.")
```

Scilab code Exa 4.6 calculate lagging

```
//Example 4.6
clc
disp("kVA = 1200,  V_L = 6600 V,  R_a = 0.25 ohm,
   X_s = 5 ohm")
disp("Now  kVA = sqrt(3)*V_L*I_L*10^-3")
il=1200/(sqrt(3)*6600*10^-3)
format(7)
disp(il,"Therefore,  I_L(in A) =")
disp("Therefore,  I_aph = 104.97 A              ... as
    star connected.")
disp("This is its full load current")
vph=6600/sqrt(3)
format(9)
disp(vph,"  V_ph(in V) = V_L/3 =")
disp("(i) For 0.8 lagging p.f. load")
disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
   sin(phi)+I_a*X_s)^2")
eph=(((3810.512*0.8)+(104.97*0.25))^2)
   +(((3810.512*0.6)+(104.97*5))^2)
p=sqrt(eph)
format(8)
```

```
disp(p,"Therefore,  E_ph(in V) = ")
regu=((4166.06-3810.512)/3810.512)*100
format(5)
disp(regu,"Therefore, %Regulation(in percentage) = (E_ph-V_ph / V_ph)*100 =")
disp("(ii) For 0.8 leading p.f. load")
disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)+I_a*X_s)^2")
eph=(((3810.512*0.8)+(104.97*0.25))^2)+(((3810.512*0.6)-(104.97*5))^2)
p=sqrt(eph)
format(8)
disp(p,"Therefore,  E_ph(in V) = ")
regu=((3543.47-3810.512)/3810.512)*100
format(5)
disp(regu,"Therefore, %Regulation(in percentage) = (E_ph-V_ph / V_ph)*100 =")
disp("The regulation is negative for leading p.f. loads")
```

Scilab code Exa 4.7 calculate full load

```
//Example 4.7
clc
disp("V_L = 866 V,  kVA = 100")
disp("Therefore,  kVA = sqrt(3)*V_L*I_L*10^-3")
il=100/(sqrt(3)*866*10^-3)
format(6)
disp(il,"Therefore,  I_L(in A) =")
disp("Therefore,  I_aph F.L. = I_L = 66.67 A                  ... as star connected alternator")
disp("V_ph = Rated terminal voltage per phase = V_L/3")
vp=866/sqrt(3)
disp(vp,"Therefore,  V_ph(in V) =")
```

```
disp("For calculation of Z_s on full load, it is
    necessary to plot O.C.C. and S.C.C. to the scale"
    )
disp("Note :  If for same value of I_f, both I_ssc
    and V_oc can be obtained from the table itself,
    graph need not be plotted. In some problems, the
    values of V_oc and I_ssc for same I_f are
    directly given, in that case too, the graph need
    not be plotted.")
disp("In this problem, I_ssc = 25 A for I_f = 1 A")
disp("But we want to calculate Z_s for I_ssc = its
    full load value which is 66.67 A. So graph is
    required to be plotted.")
disp("For plotting O.C.C. the lines values of open
    circuit voltage are converted to phase by
    dividing each value by sqrt(3)")
disp("From S.C.C.")
disp("For    I_scc = 66.67 A,   I_f = 2.4 A")
disp("From O.C.C.")
disp("For    I_f = 2.4 A,   (V_oc)_ph = 240 V")
disp("From the graph, Z_s for full load is,")
disp("Z_s = (V_oc)_ph / (I_scc)_ph |for same
    excitation")
zs=240/66.67
format(4)
disp(zs,"Therefore,  Z_s(in ohm/phase) =")
disp("R_a = 0.15 ohm/phase")
xs=sqrt((3.6^2)-(0.15^2))
format(6)
disp(xs,"Therefore,  X_s(in ohm/phase) = sqrt(Z_s^2
    - R_a^2) =")
disp("V_ph F.L = 500 V")
disp("cos(phi) = 0.8")
disp("Therefore,  sin(phi) = 0.6 lagging p.f.")
disp("So E_ph for full load, 0.8 lagging p.f.
    condition can be calculated as,")
disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
    sin(phi)+I_a*X_s)^2")
```

```
eph=(((500*0.8)+(66.67*0.15))^2)+(((500*0.6)+(66.67*3.597))^2)
p=sqrt(eph)
format(7)
disp(p,"Therefore,  E_ph(in V) = ")
regu=((677.86-500)/500)*100
format(6)
disp(regu,"Therefore, %Regulation(in percentage) = (E_ph-V_ph / V_ph)*100 =")
```

Scilab code Exa 4.8 find current

```
//Example 4.8
clc
disp("V_L = 230 V,  R_a between lines = 1.8 ohm")
disp("(V_oc)_line = 230 V,  I_scc = 12.5 A for same I_f = 0.38 A")
disp("The value of open circuit e.m.f is always line value unless and until specifically mentioned to be a phase value")
disp("Therefore,  Z_s = (V_oc)_ph / (I_scc)_ph |for same I_f")
voc=230/sqrt(3)
format(7)
disp(voc,"  (V_oc)_ph(in V) =")
zs=132.79/12.5
disp(zs,"Therefore,  Z_s(in ohm/phase) =")
disp("R_a between lines = 1.8 ohm")
disp("For star connection, R_a between the terminals is 2 R_a per ph")
disp("Therefore,  2R_a per ph = 1.8")
disp("Therefore,  R_a per ph = 0.9 ohm")
xs=sqrt((10.623^2)-(0.9^2))
format(7)
disp(xs,"Therefore,  X_s(in ohm/phase) = sqrt(Z_s^2
```

```
    - R_a^2) =")
disp("Now regulated is asked for I_a = 10 A")
disp("Now : The value of Z_s is calculated for I_s
    = 12.5 A and not at I_s = 10 A. It will be
    different for I_s = 10 A. But in this problem the
    test results are not given hence it is not
    possible to sketch the graphs to detemine Z_s at
    I_a = 10 A. So value of Z_s calculated is assumed
    to be same as I_a = 10 A")
disp("(i) For 0.8 lagging p.f.")
vph=230/sqrt(3)
format(7)
disp(vph,"V_ph(in V) = V_L/sqrt(3) =")
disp("I_a = 10 A")
disp("cos(phi) = 0.8    so sin(phi) = 0.6")
disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
    sin(phi)+I_a*X_s)^2")
eph=(((132.79*0.8)+(10*0.9))^2)+(((132.79*0.6)
    +(10*10.585))^2)
p=sqrt(eph)
format(8)
disp(p,"Therefore,  E_ph(in V) = ")
regu=((218.39-132.79)/132.79)*100
format(6)
disp(regu,"Therefore, %Regulation(in percentage) = (
    E_ph-V_ph / V_ph)*100 =")
disp("(ii) For 0.8 leading p.f.")
disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
    sin(phi)+I_a*X_s)^2")
eph=(((132.79*0.8)+(10*0.9))^2)+(((132.79*0.6)
    -(10*10.585))^2)
p=sqrt(eph)
format(8)
disp(p,"Therefore,  E_ph(in V) = ")
regu=((118.168-132.79)/132.79)*100
format(6)
disp(regu,"Therefore, %Regulation(in percentage) = (
    E_ph-V_ph / V_ph)*100 =")
```

Scilab code Exa 4.9 find armature conductors

```
//Example 4.9
clc
disp("P = 10,  N_a = 600 r.p.m,  slots = 90")
disp("phi = 16 mWb,  E_line = 11 kW")
f=6000/120
format(3)
disp("N_s = 120f / P")
disp(f,"Therefore,  f(in Hz) =")
eph=(11*10^3)/sqrt(3)
format(9)
disp(eph,"For star connection, E_ph(in V) = E_line/
    sqrt(3) =")
disp("Now  E_ph = 4.44*K_c*K_d*phi*f*T_ph")
disp("K_c = 1 as no information about short pitching
     is given")
n=90/10
disp(n,"n = slots/pole =")
m=9/3
disp(m,"m = slots/pole/phase = n/3 =")
beta=180/9
disp(beta,"beta = slot angle = 180/n =")
kd=sind(30)/(3*sind(10))
format(7)
disp(kd,"Therefore,  K_d = sin(m*beta/2) / m*sin(
    beta/2) =")
disp("Therefore,  6350.853 =
    4.44*1*0.9598*16*10^-3*50*T_ph")
tph=6350.853/(4.44*1*0.9598*16*50*10^-3)
format(5)
disp(tph,"Therefore,  T_ph =")
zph=2*1862
disp(zph,"Therefore,  Z_ph = 2*T_ph =")
```

```
disp("These are armature conductors per phase
    required to be connected in series.")
```

Scilab code Exa 4.10 calculate flux

```
//Exmaple 4.10
clc
disp("N_s = 250 r.p.m.,  f = 50 Hz")
disp("slots = 288,  E_line = 6600 V")
disp("N_s = 120*f/P")
p=(120*50)/250
format(3)
disp(p,"Therefore,  P =")
n=288/24
disp(n,"n = slots/pole =")
m=12/3
disp(m,"m = n/2 =")
beta=180/12
disp(beta,"beta = 180/n =")
kd=sind(30)/(4*sind(7.5))
format(7)
disp(kd,"Therefore,  K_d = sin(m*beta/2) / m*sin(
    beta/2) =")
disp("Now coil is short pitched by 2 slots")
al=2*15
disp(al,"Therefore,  alpha = angle of short pitch =
    2 * beta =")
kc=cosd(15)
disp(kc,"Therefore,  K_c = cos(alpha/2) =")
disp("Each coil consists of 16 turns, i.e. in a slot
     each coil side consists of 16 conductors as
    shown in the fig.4.42 and in each slot there are
    2 coil sides. So each slot consists of 16 per
    coil side x 2 i.e. 32 conductors.")
disp("Therefore,  conductors/slot = 32")
```

```
disp("Therefore,  total conductors = slots x conductors/slot")
z=288*32
format(5)
disp(z,"Therefore,  Z =")
zp=9216/3
disp(zp,"Therefore,  Z_ph = conductors/phase =")
tp=3072/2
disp(tp,"Therefore,  T_ph = Z_ph/2 = ... 2 conductors -> 1 turn")
ep=6600/sqrt(3)
format(8)
disp(ep,"Now  E_ph(in V) = E_line / sqrt(3) =")
disp("E_ph = 4.44*K_c*K_d*phi*f*T_ph")
phi=(3810.51/(4.44*0.9659*0.9576*50*1536))*10^3
format(3)
disp(phi,"Therefore,  phi(in mWb) =")
```

Scilab code Exa 4.11 find rms vlaue

```
//Example 4.11
clc
disp("P = 12,  N_s = 600 r.p.m")
f=(12*600)/120
format(3)
disp(f,"Therefore,  f(in Hz) = P*N_s/120 =")
disp("(i) Average value of e.m.f in a conductor = 2*f*phi")
rms=1.11*2*60*0.05
format(5)
disp(rms,"Therefore,  r.m.s value(in V) = 1.11*2*f*phi =")
disp("(ii) Average value of e.m.f in a turn = 4*f*phi")
disp("As 2 conductors joined properly form a turn")
```

```
rms=1.11*4*60*0.05
format(6)
disp(rms,"Therefore,  r.m.s value(in V) = 1.11*4*f*phi =")
disp("(iii) Now each slot has 10 conductors and 2 coil sides. So,")
c=10/2
disp(c,"conductors/coil side = 10/2 =")
disp("Such coil sides are connected to another coil sides to form a coil. So in a coil there are 5 turns as shown in fig.4.43")
rmss=13.32*5
format(5)
disp(rmss,"Therefore,  R.M.S value of e.m.f in a coil(in V) = R.M.S value of e.m.f/turn * Number of turns/coil =")
disp("(iv) Now total conductors  Z = conductors/slots * Number of slots")
z=10*180
disp(z,"Therefore,  Z =")
zph=1800/3
disp(zph,"Therefore,  Z_ph = Z/3 =")
tph=600/2
disp(tph,"T_ph = Z_ph/2 =")
n=180/12
disp(n,"And  n = slots/pole =")
m=15/3
disp(m,"m = n/3 =")
beta=180/15
disp(beta,"beta(in degree) =")
kd=sind(30)/(5*sind(6))
format(7)
disp(kd,"Therefore,  K_d = sin(m*beta/2) / m*sin(beta/2) =")
disp("E_ph = R.M.S value per turn*T_ph*K_d*K_c")
ep=13.32*300*0.9566*1
format(8)
disp(ep,"Therefore,  E_ph(in V) =")
```

```
disp("or  E_ph = 4.44*K_c*K_d*phi*f*T_ph")
eph=4.44*0.9566*0.05*60*300
format(8)
disp(eph,"Therefore,  E_ph(in V) =")
```

Scilab code Exa 4.12 find induced emf

```
//Example 4.12
clc
disp("P = 6,  f = 50 Hz,  n = 12 slots/pole, 4 conductors/slot")
disp("For full pitch,  n = 12 slots/pole")
ap=60/6
format(4)
disp(ap,"Actual pitch of winding(in slots) = 5/6 * n =")
ws=12-10
disp(ws,"so winding shorted by(in slots) =")
disp("Therefore,  alpha = short pitch angle = 2 slot angle = 2*beta")
beta=180/12
disp(beta,"beta(in degree) =")
alp=2*15
disp(alp,"Therefore,  alpha(in degree) = 2*beta =")
kc=cosd(15)
format(7)
disp(kc,"Therefore,  K_c = cos(alpha/2) =")
m=12/3
disp(m,"m(in slots/pole/phase) = n/3 =")
kd=sind(30)/(4*sind(7.5))
format(8)
disp(kd,"Therefore,  K_d = sin(m*beta/2) / m*sin(beta/2) =")
ts=12*6
disp(ts,"Total slots = n*P =")
```

```
z=72*4
disp(z,"Therefore, Z = total conductors =")
zph=288/3
disp(zph,"Therefore, Z_ph = Z/3 =")
tph=96/2
disp(tph,"T_ph = Z_ph/2 =")
disp("Therefore, E_ph = 4.44*K_c*K_d*phi*f*T_ph")
eph=(4.44*0.9659*0.95766*1.5*50*48)*10^-3
format(8)
disp(eph,"Therefore, E_ph(in kV) =")
el=sqrt(3)*14.7852
disp(el,"Therefore, E_line(in kV) = sqrt(3)*E_ph =")
```

Scilab code Exa 4.13 find chording factor

```
//Example 4.13
clc
disp("The coil span of 120 degree is shown in the fig.4.44")
disp("The angle of shorts pitch is,")
alp=180-120
format(3)
disp(alp,"alpha(in degree) = 180 - coil span =")
kc=cosd(30)
format(6)
disp("The chording factor is,")
disp(kc,"K_c = cos(alpha/2) =")
```

Scilab code Exa 4.14 find emf

```
//Example 4.14
clc
```

```
disp("V_ph = 200 V, 60 kVA,  R_a = 0.016 ohm,  X_s = 0.07 ohm")
disp("VA = V_ph*I_ph    i.e. 60*10^3 = 200*I_ph    ...Single phase")
disp("Therefore,  I_ph = 300 A = I_a    ...Full load current")
disp("(a) cos(phi) = 1,  sin(phi) = 0")
eph=sqrt((((200+((300*0.016)))^2)+((300*0.07)^2)))
disp("Therefore,  E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (I_a*X_a)^2")
format(9)
disp(eph,"E_ph(in V) =")
disp("(b) cos(phi) = 0.7 lagging,  sin(phi) = 0.714")
ephi=sqrt(((((200*0.7)+(300*0.016))^2)+(((200*0.7141)+(300*0.07))^2)))
disp("Therefore,  E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)+I_a*R_a)^2")
format(9)
disp(ephi,"E_ph(in V) =")
```

Scilab code Exa 4.15 find reactance

```
//Example 4.15
clc
disp("V_ph = 550 V, 55 kVA,  R_a = 0.2 ohm")
disp("I_f = 10 A,  I_ssc = 200 A,  V_oc = 450 V")
za=450/200
format(5)
disp(za,"Therefore,  Z_s(in ohm) = V_oc / I_ssc | same I_f =")
xs=sqrt((2.25^2)-(0.2^2))
format(7)
disp(xs,"(a)  X_s(in ohm) = sqrt(Z_a^2 - R_a^2) =")
iph=(55*10^3)/550
```

```
disp("VA = V_ph*I_ph                ...As single phase")
disp(iph,"Therefore, I_ph(in A) = I_a =           ...
   Full load armature current")
disp("(b) cos(phi) = 0.8 lagging, sin(phi) = 0.6")
ephi=sqrt(((((550*0.8)+(100*0.2))^2)+(((550*0.6)
   +(100*2.2411))^2)))
disp("Therefore, E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
    + (V_ph*sin(phi)+I_a*R_a)^2")
format(9)
disp(ephi,"E_ph(in V) =")
r=((720.1652-550)/550)*100
format(6)
disp(r,"Therefore, %R = (E_ph-V_ph / V_ph)*100 = ")
```

Scilab code Exa 4.16 find impedence

```
//Example 4.16
clc
disp("V_ph = 2200 V, f = 50 Hz, 440 kVA, R_a = 0.5
    ohm")
disp("I_aph = 200 A = I_ac, V_oc = 1160 V, I_f =
   40 A")
za=1160/200
format(4)
disp(za,"(a) Z_s(in ohm) = V_oc/I_ssc |same I_f =")
xs=sqrt((5.8^2)-(0.5^2))
format(7)
disp(xs,"(b) X_s(in ohm) = sqrt(Z_a^2 - R_a^2) =")
disp("(c) cos(phi) = 0.707 leading, sin(phi) =
   0.707")
ephi=sqrt(((((2200*0.707)+(200*0.5))^2)
   +(((2200*0.707)-(200*5.7784))^2)))
disp("Therefore, E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
    + (V_ph*sin(phi)-I_a*R_a)^2")
format(10)
```

```
disp(ephi,"E_ph(in V) =")
r=((1702.9754-2200)/2200)*100
format(7)
disp(r,"Therefore, %R(in percentage) = (E_ph-V_ph / V_ph)*100 = ")
```

Scilab code Exa 4.17 find voltage regulation

```
//Example 4.17
clc
disp("Assume star connected alternator")
disp("R_a+R_a = V_dc/I_dc")
disp("2R_a = 6/10")
ra=0.6/2
format(4)
disp(ra,"Therefore, R_a(in ohm/ph) =")
disp("V_oc(line) = 420, V_L = 1100 V, 100 kVA")
disp("Therefore, VA = sqrt(3)*V_L*I_L")
il=(100*10^3)/(sqrt(3)*1100)
format(8)
disp(il,"Therefore, I_L(in A) = I_aph =")
disp("Therefore, Rated armature current = 52.4864 A = I_ssc")
zs=(420/sqrt(3))/52.4864
format(5)
disp(zs,"Therefore, Z_s(in ohm/ph) = V_oc(ph) / I_ssc(ph) =")
xs=sqrt((4.62^2)-(0.3^2))
format(7)
disp(xs,"Therefore, X_s(in ohm/ph) = sqrt(Z_a^2 - R_a^2) =")
disp("For cos(phi) = 0.8 lagging, sin(phi) = 0.6")
disp("E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)+I_a*R_a)^2")
vph=1100/sqrt(3)
```

```
format(8)
disp(vph,"V_ph(in V) = V_L/sqrt(3) =")
ephi=sqrt(((((635.085*0.8)+(52.4864*0.3))^2)
    +(((635.085*0.6)+(52.4864*4.6102))^2)))
format(9)
disp(ephi,"Therefore,  E_ph(in V) =")
r=((813.9654-635.085)/635.085)*100
format(8)
disp(r,"Therefore,  %R(in percentage) = (E_ph-V_ph /
     V_ph)*100 = ")
```

Scilab code Exa 4.18 find regulation

```
//Example 4.18
clc
disp("2R_a = 2  i.e.  R_a = 1 ohm/ph")
disp("V_L = 3.6 kVA,  MVA = 1")
disp("Therefore,  VA = sqrt(3)*V_L*I_L")
il=(1*10^6)/(sqrt(3)*3.6*10^3)
format(8)
disp(il,"Therefore,  I_L(in A) = I_aph =          ...
    Star")
disp("From the test results, obtain the open circuit
     and short circuit characteristics and obtain
    V_oc for full load I_sc of 160.373 A")
disp("From the graph, for full load short circuit
    current of 160.37 A, I_f = 53 A and corresponding
     V_oc(line) = 2250 V")
zs=(2250/sqrt(3))/160.37
format(4)
disp(zs,"Therefore,  Z_s(in ohm/ph) = V_ocph/I_scph
    |same I_f =")
xs=sqrt((8.1^2)-(1^2))
format(6)
disp(xs,"Therefore,  X_s(in ohm/ph) = sqrt(Z_a^2 -
```

```
    R_a^2) =")
vph=(3.6*10^3)/sqrt(3)
format(8)
disp(vph,"V_ph(in V) = V_L/sqrt(3) =")
disp("I_aph = 160.37 A")
disp("(i) cos(phi) = 0.707 lagging, sin(phi) =
    0.707")
disp("Therefore, E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
     + (V_ph*sin(phi)+I_a*R_a)^2")
ephi=sqrt(((((2078.46*0.707)+(160.37*1))^2)
    +(((2078.46*0.707)+(160.37*8.038))^2)))
format(10)
disp(ephi,"Therefore, E_ph(in V) =")
r=((3204.0356-2078.46)/2078.46)*100
format(6)
disp(r,"Therefore, %R(in percentage) = (E_ph-V_ph /
     V_ph)*100 = ")
disp("(ii) cos(phi) = 0.8 leading, sin(phi) = 0.6"
    )
disp("Therefore, E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
     + (V_ph*sin(phi)-I_a*R_a)^2")
ephi=sqrt(((((2078.46*0.8)+(160.37*1))^2)
    +(((2078.46*0.6)-(160.37*8.038))^2)))
format(10)
disp(ephi,"Substituting the values, E_ph(in V) =")
r=((1823.6271-2078.46)/2078.46)*100
format(6)
disp(r,"Therefore, %R(in percentage) = (E_ph-V_ph /
     V_ph)*100 = ")
```

Scilab code Exa 4.19 find regulation

```
//Example 4.19
clc
disp("1 MVA, V_L = 11 kV, R_a = 0.6 ohm")
```

```
disp("VA = sqrt(3)*V_L*I_L")
il=(10^6)/(sqrt(3)*11*10^3)
format(7)
disp(il,"Therefore,  I_L(in A) = I_aph(full load) =")
disp("Now I_f = 40 A for I_ssc = 52.486 A. To find Z_s, plot the O.C.C and obtain V_oc for I_f = 40 A")
disp("From the graph, V_oc(line) = 6600 V for I_f = 40 A")
zs=(6000/sqrt(3))/52.486
format(3)
disp(zs,"Therefore,  Z_s(in ohm) = V_ocph/I_ascph | same I_f =")
xs=sqrt((66^2)-(0.6^2))
format(7)
disp(xs,"Therefore,  X_s(in ohm) = sqrt(Z_s^2 - R_a^2) =")
disp("(a) cos(phi) = 0.8 lagging,  sin(phi) = 0.6, half load")
ip=0.5*52.486
format(7)
disp(ip,"At half load,  I_aph(in A) = 1/2 * I_aph(FL) =")
vp=(11*10^3)/sqrt(3)
format(9)
disp(vp,"V_ph(in V) = V_L/sqrt(3) =")
disp("E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)+I_a*R_a)^2")
ephi=sqrt(((((6350.853*0.8)+(26.243*0.6))^2)+(((6350.853*0.6)+(26.243*65.99))^2)))
format(10)
disp(ephi,"Therefore,  E_ph(in V) =")
r=((7529.3113-6350.853)/6350.853)*100
format(6)
disp(r,"Therefore,  %R(in percentage) = (E_ph-V_ph / V_ph)*100 = ")
disp("(b) cos(phi) = 0.9 leading,  sin(phi) =
```

```
0.4358, full load so I_aph = 52.486 A")
disp("E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)-I_a*R_a)^2")
ephi=sqrt(((((6350.853*0.9)+(52.486*0.6))^2)+(((6350.853*0.4358)-(52.486*65.99))^2)))
format(9)
disp(ephi,"Therefore, E_ph(in V) =")
r=((5789.231-6350.853)/6350.853)*100
format(6)
disp(r,"Therefore, %R(in percentage) = (E_ph-V_ph / V_ph)*100 = ")
```

Scilab code Exa 4.20 find voltage

```
//Example 4.20
clc
disp("R_s = 0.6 ohm, X_s = 6 ohm, I_aph = 180 A")
eph=6599/sqrt(3)
format(10)
disp(eph,"E_ph(in V) = E_line/sqrt(3) =")
disp("(a) cos(phi) = 0.9 lagging, sin(phi) = 0.4358")
disp("Therefore, E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)+I_a*R_a)^2")
disp("Therefore, (3809.9344)^2 = [V_ph*0.9 + 180*0.6]^2 + [V_ph*0.4358 + 180*6]^2")
disp("Therefore, 14.5156*10^6 = 0.81*V_ph^2 + 194.4*V_ph + 11664 + 0.1899*V_ph^2 + 941.328*V_ph + 1166400")
disp("Therefore, V_ph^2 + 1135.728*V_ph - 13337536 = 0")
disp("Therefore, V_ph = 3128.08, -4263.808 ...Neglect negative value")
disp("Therefore, V_ph = 3128.08 V ...Terminal voltage")
```

```
r=((3809.9344-3128.08)/3128.08)*100
format(8)
disp(r,"Therefore, %R(in percentage) = (E_ph-V_ph / V_ph)*100 = ")
disp("(b) cos(phi) = 0.8 leading, sin(phi) = 0.6")
disp("Therefore, E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin(phi)+I_a*R_a)^2")
disp("Therefore, (3809.9344)^2 = [V_ph*0.8 + 180*0.6]^2 + [V_ph*0.6 + 180*6]^2")
disp("Therefore, 14.5156*10^6 = 0.64*V_ph^2 + 172.8*V_ph + 11664 + 0.36*V_ph^2 - 1296*V_ph + 1166400")
disp("Therefore, V_ph^2 - 1123.2*V_ph - 13337536 = 0")
disp("Therefore, V_ph = 4256.5872 V          ...Neglect negative value")
r=((3809.9344-4256.5872)/4256.5872)*100
format(7)
disp(r,"Therefore, %R(in percentage) = (E_ph-V_ph / V_ph)*100 = ")
```

Scilab code Exa 4.21 calculate regulation

```
//Example 4.21
clc
disp("1500 kVA, V_L = 12 kV, R_a = 2 ohm, X_s = 10 ohm")
vp=(12*10^3)/sqrt(3)
format(10)
disp(vp," V_ph(in V) =          ...Star")
disp("P_L = sqrt(3)*V_L*I_L*cos(phi)")
disp("(a) cos(phi) = 0.8 lagging, sin(phi) = 0.6")
il=(1200*10^3)/(sqrt(3)*0.8*12*10^3)
format(7)
disp(il,"Therefore, I_L(in A) = I_aph =          ...
```

```
    Star")
disp("  E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
    sin(phi)+I_a*R_a)^2")
ephi=sqrt(((((6928.2032*0.8)+(72.168*2))^2)
    +(((6928.2032*0.6)+(72.168*10))^2)))
format(9)
disp(ephi,"Therefore,  E_ph(in V) =")
r=((7492.768-6928.2032)/6928.2032)*100
format(6)
disp(r,"Therefore,  %R(in percentage) = (E_ph-V_ph /
     V_ph)*100 = ")
disp("(b) cos(phi) = 0.707 leading,  sin(phi) =
    0.707")
il=(1200*10^3)/(sqrt(3)*0.707*12*10^3)
format(6)
disp(il,"Therefore,  I_L(in A) = I_a =            ...
    Star")
disp("  E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
    sin(phi)+I_a*R_a)^2")
ephi=sqrt(((((6928.2032*0.707)+(81.66*2))^2)
    +(((6928.2032*0.707)-(81.66*10))^2)))
format(10)
disp(ephi,"Therefore,  E_ph(in V) =")
r=((6502.2433-6928.2032)/6928.2032)*100
format(6)
disp(r,"Therefore,  %R(in percentage) = (E_ph-V_ph /
     V_ph)*100 = ")
```

Chapter 5

Alternators

Scilab code Exa 5.1 calculate full load slip

```
//Example 5.1
clc
disp("Given values are,")
disp("P = 4, f = 50 Hz,  N = 1410 r.p.m")
ns=(120*50)/4
disp(ns,"N_s(in r.p.m) = 120*f / P =")
disp("Full load absolute slip is given by,")
s=((1500-1410)/1500)
format(5)
disp(s,"s = N_s-N / N_s =")
s=0.06*100
disp(s,"Therefore,  %s =")
```

Scilab code Exa 5.2 calculate full load speed

```
//Example 5.2
clc
disp("Given values are,")
```

```
disp("P = 4, f = 50 Hz,  %s = 4%")
disp("s = Full load absolute slip = 0.04")
ns=(120*50)/4
disp(ns,"N_s(in r.p.m) = 120*f / P =")
disp("s = N_s-N / N_s    where N_s = full load speed
    of motor")
disp("0.04 = 1500-N_s / 1500")
ns=1500-(1500*0.04)
disp(ns,"Therefore,  N_s(in r.p.m) =")
disp("This is the full load speed of the motor")
```

Scilab code Exa 5.3 frequency of induced emf

```
//Example 5.3. frequency of induced emf in the rotor
clc
disp("The given values are,")
disp("P = 4,  f = 50 Hz,  N = 1470 r.p.m")
ns=(120*50)/4
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
s=(1500-1470)/1500
disp(s,"s = N_s-N / N_s =")
f=0.02*50
disp(f,"Therefore,  f_r(in Hz) = s*f =")
```

Scilab code Exa 5.4 find full load slip

```
//Example 5.4
clc
disp("The given values are,")
disp("P = 8,  f = 50 Hz,  f_r = 2 Hz")
disp("Now    f_r = s*f")
s=2/50
```

```
format(5)
disp(s,"Therefore ,  s =")
sp=0.04*100
disp(sp,"Therefore ,  %s =                  ...Full load
    slip")
disp("The corresponding speed is given by,")
disp("N = N_s*(1-s)                    ...From s = N_s-N
    / N_s")
ns=(120*50)/8
disp(ns,"where     N_s(in r.p.m) = 120f/P =")
n=750*(1-0.04)
disp(n,"Therefore ,  N(in r.p.m) =              ...Full
    load speed")
```

Scilab code Exa 5.5 calculate frequency

```
//Example 5.6
clc
disp("The given values are , K = Rotor turns/Stator
    turns = 1/2 = 0.5 and")
disp("P = 4, f = 50 Hz, N = 1455 r.p.m, E_line = 415
    V")
ns=(120*50)/4
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
disp("For a given load , N = 1455 r.p.m")
s=(1500-1455)/1500
disp(s,"Therefore ,  s = N_s-N / N_s =")
f=0.03*50
disp(f,"(i)  f_r(in Hz) = s*f =")
disp("(ii) At standstill , induction motor acts as a
    transformer so,")
disp("E_2ph/E_1ph = rotor turns/stator turns = K")
disp("But ratio of stator to rotor turns is given as
    2, i.e.")
```

```
disp("  N1/N2 = 2       Therefore ,  N2/N1 = 1/2 = K")
disp("and  E_1line = 415 V")
disp("The given values are always line values unless and until specifically stated as per phase.")
e1=415/sqrt(3)
format(6)
disp(e1,"Therefore ,  E_1ph(in V) = E_1/sqrt(3) =               ...As star connection E_line = sqrt(3)*E_ph")
disp("Therefore ,  E_2ph/E_1ph = 1/2")
e2=239.6/2
disp(e2,"Therefore ,  E_2ph(in V) =                 ...Rotor induced e.m.f on standstill")
disp("(iii) In running condition ,")
er=0.03*119.8
disp(er,"E_2r(in V) = s*E_2 =")
disp("The value of rotor induced e.m.f in the running condition is also very very small")
```

Scilab code Exa 5.6 find rotor current

```
//Example 5.6
clc
disp("The given values are ,")
disp("P = 4 ,  f = 50 Hz ,  R2 = 0.2 ohm ,  X2 = 1 ohm")
disp("Now open circuit e.m.f between slip rings means rotor induced e.m.f on standstill. As long as rotor is open , there cannot be rotor current rotation of rotor. And between the slip rings means its a line value of E2 , for a star connected rotor. The open circuit e.m.f is shown in fig.5.15")
disp("Therefore ,  E_2line = 120 V,  for star E_2line = sqrt(3)*E_2ph")
e2=120/sqrt(3)
```

```
format(6)
disp(e2,"Therefore,  E_2ph(in V) = E_2/sqrt(3) =")
ns=(120*50)/4
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
disp("(i) At start,")
cp=0.2/(sqrt((0.2^2)+1))
format(6)
disp(cp,"cos(phi) = R2/Z2 = R2 / sqrt(R2^2+X2^2) =")
i2=69.28/(sqrt((0.2^2)+1))
disp(i2,"I2(in A/phase) = E2/Z2 = E2 / sqrt(R2^2+X2
    ^2) =")
disp("(ii) On full load, N = 1440 r.p.m")
s=(1500-1440)/1500
format(5)
disp(s,"Therefore,  s = N_s-N / N_s =")
cpr=0.2/(sqrt((0.2^2)+(0.04^2)))
format(7)
disp(cpr,"Therefore,  cos(phi)_2r = R2/Z_2r = R2 /
    sqrt(R2^2+(s*X2)^2) =")
i2r=(0.04*69.28)/(sqrt((0.2^2)+(0.04^2)))
disp(i2r,"Therefore,  I_2r(in A) = E_2r/Z_2r = s*E2
    / sqrt(R2^2+(s*X2)^2) =")
disp("It can be observed that current is drastically
     reduced from its value at start. In the running
    condition, slip controls and limits the magnitude
     of the motor current")
```

Scilab code Exa 5.7 calculate torque developed

```
//Example 5.7 calculate torque developed on full
    load by the motor.
clc
disp("P = 4, f = 50 Hz, R2 = 0.1 ohm, X2 = 1 ohm, N
    = 1440 r.p.m")
```

```
disp("Stator turns/Rotor turns = 2/1")
disp("Therefore, K = E2/E1 = Rotor turns/Stator turns = 1/2 = 0.5")
ns=(120*50)/4
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
disp("E_1line = 400 V                    ...Stator line voltage given")
e1=400/sqrt(3)
format(7)
disp(e1,"Therefore, E_1ph(in V) = E_1line/sqrt(3) = ")
disp("But  E_2ph/E_1ph = 0.5 = K")
e2=230.94/2
disp(e2,"Therefore, E_2ph(in V) =")
s=(1500-1440)/1500
format(5)
disp(s,"Full load slip, s = N_s-N / N_s =")
ns=1500/60
disp("n_s(in r.p.s) = Synchoronous speed in r.p.s")
disp(ns,"                    = N_s/60 =")
t=(3/(2*%pi*25))*((0.04*0.1*115.47^2)/((0.1^2)+(0.04^2)))
format(6)
disp(t,"T(in N-m) = (3 / 2*pi*ns) * (s*E2^2*R2 / R2^2+(s*X2)^2) =")
```

Scilab code Exa 5.8 find torque

```
//Example 5.8
clc
disp("P = 4, f = 50 Hz, Stator turns/Rotor turns = 4, R2 = 0.01 ohm, X2 = 0.1 ohm")
disp("E_1line = stator line voltage = 400 V")
e1=400/sqrt(3)
```

```
format(7)
disp(e1,"E_1ph(in V) = E_1line/sqrt(3) = ...star connection")
disp("K = E_2ph/E_1ph = Rotor turns/stator turns = 1/4")
e2=230.94/4
disp(e2,"Therefore,  E_2(in V) = 1/4 * E_1ph =")
ns=(120*50)/4
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
disp("(i) At start,  s = 1")
disp("Therefore,  T_st =  (k*E2^2*R2 / R2^2+X2^2)     where k = 3 / 2*pi*ns")
ns=1500/60
disp(ns,"n_s(in r.p.s) = N_s/60 =")
k=3/(2*%pi*25)
format(8)
disp(k,"Therefore,  k = 3 / 2*pi*25 =")
t=((0.01909*0.01*57.735^2)/((0.01^2)+(0.1^2)))
format(7)
disp(t,"Therefore,  T_st(in N-m) =")
disp("(ii) Slip at which maximum torque occurs is,")
sm=0.01/0.1
disp(sm,"s_m = R2/X2 =")
psm=0.1*100
disp(psm,"%s_m =")
disp("(iii) Speed at which maximum torque occurs is speed corresponding to s_m,")
n=1500*(1-0.1)
format(5)
disp(n,"N(in r.p.m) = N_s*(1-s_m) =")
disp("(iv) The maximum torque is,")
tm=(0.01909*57.735^2)/(2*0.1)
format(7)
disp(tm,"T_m(in N-m) = k*E2^2 / 2*X2 =")
disp("(v) Full load slip, s_f = 0.04     as %s_f = 4%")
t=((0.01909*0.04*0.01*57.735^2)/((0.01^2)+(0.004^2))
```

```
    )
format(7)
disp(t,"T_f.l(in N-m) =(k*s*E2^2*R2 / R2^2+(s_f*X2)
    ^2) =")
```

Scilab code Exa 5.9 find ratio of torque

```
//Exmaple 5.9
clc
disp("Given values are,")
disp("P = 24, f = 50 Hz, R2 = 0.016 ohm, X2 = 0.265
    ohm, N = 247 r.p.m")
ns=(120*50)/24
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
s=(250-247)/250
format(6)
disp(s,"s_f = Full load slip = N_s-N / N_s =")
sm=0.016/0.265
format(8)
disp(sm,"s_m = R2/X2 =")
tf=(2*0.06037*0.012)/((0.06037^2)+(0.012^2))
format(7)
disp(tf,"(i) T_F.L/T_m = 2*s_m*s_f / s_m^2+s_f^2 =")
ts=(2*0.06037)/((0.06037^2)+(1^2))
format(7)
disp(ts,"(ii) T_st/T_m = 2*s_m / 1+s_m^2 =")
```

Scilab code Exa 5.10 find slip

```
//Example 5.10 slip, net o/p power, rotor copper
    loss/phase, efficiency and resistance
clc
```

```
disp("The given values are,")
disp("P = 4, f = 50 Hz, T_sh = 300 N-m, T_lost = 50 N-m")
disp("Rotor frequency  = 120 cycles/min = 120/60 cycles/sec i.e. Hz")
disp("i.e.  f_r = 2 Hz")
disp("(i)  f_r = s*f")
s=2/50
format(5)
disp(s,"Therefore,  s = f_r/f =")
disp("(ii)  P_out = T_sh * omega = T_sh * 2*pi*N/60")
disp("Now  N = N_s(1-s)     at slip s = 0.04")
ns=(120*50)/4
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
n=1500*(1-0.04)
disp(n,"Therefore,  N(in r.p.m) = N_s(1-s) =")
po=(300*((2*%pi*1440)/60))*10^-3
format(8)
disp(po,"Therefore,  P_out(in kW) =")
disp("Remember that T_sh is not output torque available to load at shaft")
disp("(iii)  T_lost = 50 Nm in fiction")
f=50*((2*%pi*1440)/60)
format(9)
disp(f,"Therefore,  Frictional loss(in W) = T_lost * omega = T_lost * 2*pi*N/60 =")
disp("Now  P_out = P_in - frictional loss")
pin=45.2389+7.539822
disp(pin,"Therefore,  P_in(in kW) = P_out + frictional loss =")
disp("  We know, P_2:P_c:P_m  is  1:s:1-s")
disp("Therefore,  P_c/P_m = s/1-s")
pc=(52.77872*10^3)*(0.04/(1-0.04))
format(10)
disp(pc,"Therefore,  P_c(in W) = P_m * (s/1-s) =")
disp("These are total rotor copper losses")
```

```
rc=2199.1134/3
format(9)
disp(rc,"Therefore,  Rotor copper loss per phase(in
    W) = P_c/3 =")
disp("(iv)  Rotor efficiency = (Rotor output P_in /
    Rotor input P2)*100")
p2=2199.1134/0.04
format(12)
disp(p2,"Now  P2(in W) = P_c/s =")
re=52778.72*100/54977.83
format(3)
disp(re,"Therefore,  % Rotor eta(in percentage) =")
disp("(v)  I_2r = 60 A      given per phase")
disp("now  Rotor copper loss/ph = I_2r^2 * R2")
r2=733.0378/60^2
format(7)
disp(r2,"Therefore,  R2(in ohm/ph) =")
```

Scilab code Exa 5.11 find shaft torque

```
//Example 5.11
clc
disp("P_out = 24 kW,  I_L = 57 A")
disp("P = 8, N = 720 r.p.m,  f = 50 Hz")
disp("I_L = 415 V,  cos(phi) = 0.707")
ns=(120*50)/8
format(4)
disp(ns,"N_s(in r.p.m) = 120f/P =")
s=(750-720)/750
format(5)
disp(s,"Therefore,  s = N_s-N / N_s =")
disp("P_m - mechanical loss = P_out")
pin=24000+1000
format(6)
disp(pin,"Therefore,  P_in(in W) = P_out +
```

```
mechanical loss = 24*10^3 + 1000 =")
disp("For rotor P2:P_c:P_m is 1:s:1-s")
disp("Therefore, P_c/P_m = s/1-s")
pc=(25000)*(0.04/(1-0.04))
format(8)
disp(pc,"Therefore, P_c(in W) = P_m * (s/1-s) =")
po=((24*10^3)/((2*%pi*720)/60))
format(8)
disp(po,"(i) Shaft torque T_sh(in Nm) = P_out/omega = P_out / (2*pi*N/60) =")
t=((25*10^3)/((2*%pi*720)/60))
disp(t,"(ii) Gross torque T(in Nm) = P_out/omega = P_out / (2*pi*N/60) =")
disp("(iii) Rotor copper losses = 1041.66 W")
disp("Now P2/P_c = 1/s")
p2=1041.66/0.04
disp(p2,"Therefore, P2(in W) = P_c/s =")
pin=sqrt(3)*415*57*0.707
format(9)
disp(pin,"And net input P_in(in W) = sqrt(3)*V_L*I_L*cos(phi) =")
disp("Stator current per phase = I_L = 57 A (as star connected)")
disp("R_s = Stator resistance per phase = 0.1 ohm")
st=3*(57^2)*0.1
format(6)
disp(st,"Therefore, Stator copper losses(in W) = 3*I_s^2*R_s")
disp("Now P_in - Stator losses = P_2")
sl=28966.96-26041.5
format(8)
disp(sl,"Therefore, Stator losses(in W) =")
disp("But Stator losses = Stator iron loss + Stator copper loss")
stp=2925.46-974.7
disp(stp,"Therefore, Stator iron losses(in W) =")
disp("(iv) Stator copper losses = 974.7 W")
disp("(v) Stator iron losses = 1950.76 W")
```

```
eta=(100*24*10^3)/28966.96
format(6)
disp(eta,"(iv) % eta(in percentage) = P_out/P_in *
    100 =")
```

Scilab code Exa 5.15 find starting torque

```
//Example 5.15
clc
disp("P = 12, f = 50 Hz, R2 = 0.15 ohm, X2 = 0.25
    ohm, E2 = 32 V per phase given")
disp("Now  T =  (k*s*E2^2*R2 / R2^2+s*X2^2)
    where k = 3 / 2*pi*ns")
ns=(120*50)/12
format(4)
disp(ns,"N_s(in r.p.m) = 120f/P =")
ns=500/60
format(5)
disp(ns,"n_s(in r.p.s) = N_s/60 =")
tf=(3/(2*%pi*8.33))*((0.15*32^2)/((0.15^2)+(0.25^2))
    )
format(7)
disp(tf,"(i) T_st = (k*E2^2*R2 / R2^2+X2^2) = (3/2*
    pi*ns)*(k*E2^2*R2 / R2^2+X2^2) =")
disp("(ii) At  N = 480 r.p.m")
s=(500-480)/500
format(5)
disp(s,"s = N_s-N / N_s =")
tfi=(3/(2*%pi*8.33))*((0.04*0.15*32^2)/((0.15^2)
    +((0.04*0.25)^2)))
format(7)
disp(tfi,"Therefore,  T_F.L(in Nm) = (3/2*pi*ns)*(s*
    E2^2*R2 / R2^2+s*X2^2) =")
disp("(iii)  T_m = (3/2*pi*ns)*(E2^2 / 2*X2)
    substituting s_m = R2/X2")
```

```
tm=(3/(2*%pi*8.33))*((32^2)/(2*0.25))
format(8)
disp(tm,"Therefore, T_m(in Nm) =")
sm=0.15/0.25
format(4)
disp(sm,"(iv) Slip at T_m is, s_m = R2/X2 =")
n=500*(1-0.6)
format(4)
disp(n,"Therefore, N(in r.p.m) = N_s*(1-s_m) =")
```

Scilab code Exa 5.18 find speed of motor

```
//Example 5.18
clc
disp("P = 8, f = 50 Hz, f_s = 1.5 Hz")
disp("f_s = s*f")
s=1.5/50
format(5)
disp(s,"Therefore, s =                ...Slip")
ns=(120*50)/8
format(4)
disp(ns,"N_s(in r.p.m) = 120f/P =")
n=750*(1-0.03)
format(6)
disp(n,"N(in r.p.m) = N_s*(1-s_m) =
                    ...Speed of the motor")
```

Scilab code Exa 5.19 find rotor input

```
//Example 5.19
clc
disp("P = 4, f = 50 Hz, T_sh = 159 Nm, s = 5% = 0.05
   ")
```

```
ns=(120*50)/4
format(5)
disp(ns,"N_s(in r.p.m) = 120f/P =")
n=1500*(1-0.05)
disp(n,"Therefore, N(in r.p.m) = N_s*(1-s_m) =")
po=159*((2*%pi*1425)/60)
format(11)
disp(po,"Therefore, P_out(in W) = T_sh * omega =")
pm=23726.8785+500
disp(pm,"Therefore, P_m(in W) = P_out + Friction and windage loss =")
disp("(a) P_2:P_c:P_m is 1:s:1-s")
p2=24226.8785/(1-0.05)
disp("Therefore, P_2/P_m = 1/1-s")
disp(p2,"Therefore, P_2(in W) =                    ... Rotor input")
pi=25501.9774+1000
disp(pi,"(b) P_in(in W) = P_2 + Stator losses =              ...Motor input")
eta=(23726.8785/26501.9774)*100
format(7)
disp(eta,"(e) %eta(in percentage) = P_out/P_in * 100 =")
```

Scilab code Exa 5.22 find speeds

```
//Example 5.22
clc
disp("P = 6, f = 50 Hz, s_0 = 1%, s_a = 3%")
ns=(120*50)/6
format(5)
disp(ns,"(a) N_s(in r.p.m) = 120f/P =              ...Synchronous speed")
n=1000*(1-0.01)
format(4)
```

```
disp(n,"(b) N_0(in r.p.m) = N_s*(1-s_0) = ...No load speed")
n=1000*(1-0.03)
format(6)
disp(n,"(c) N_ft(in r.p.m) = N_s*(1-s_a) = ...Full load speed")
disp("(d) Frequency of rotor current at standstill = f = 50 Hz")
sa=0.03*50
disp(sa,"(e) Frequency of rotor current at full load (in Hz) = s_a*f =")
```

Scilab code Exa 5.23 find resistance

```
//Example 5.23
clc
disp("P = 6, f = 50 Hz, I_2r = 40 A, N = 960 r.p.m")
ns=(120*50)/6
format(5)
disp(ns,"Therefore, N_s(in r.p.m) = 120f/P =")
s=40/1000
disp(s,"Therefore, s = N_s-N / N_s =")
po=50*735.5
format(6)
disp(po,"P_out(in W) = 50*H.P = ...1 H.P = 735.5 W")
pin=36775+1200+300
disp(pin,"P_in(in W) = P_out + Mechanical losses + Gear loss =")
disp("Now P_2:P_c:P_m is 1:s:1-s")
disp("Therefore, P_c/P_m = s/1-s")
pc=(38275*0.04)/(1-0.04)
format(10)
disp(pc,"Therefore, P_c(in W) = ... Total rotor copper loss")
```

```
r2=1594.7916/(3*40^2)
format(7)
disp("Now  P_c = 3 * I_2r^2 * R2")
disp(r2,"Therefore,  R2(in ohm/ph) =")
```

Chapter 6

Instruments

Scilab code Exa 6.1 deflection

```
//exmaple6.1
clc
disp("The deflecting torque is given by,")
disp("(T_d)=NBAI=100*15*A*5*10^-3 Nm")
disp("Now A= Area = 10*8 =80 mm^2= 80*10^-6 m^2")
t=100*0.15*80*5*10^-9
disp(t,"Therefore, (T_d)[in Nm]=100*0.15*80*(10^-6)
    *5*(10^-3)=")
disp("Now, T_d=T_c=K*(theta)")
disp("Therefore, 6*10^-6 = 0.2*10^-6 *(theta)")
t=(6*10^-6)/(0.2*10^-6)
disp(t,"Therefore, theta(in degree)=(6*10^-6)
    /(0.2*10^-6)= ")
```

Scilab code Exa 6.2 theta

```
//example6.2
clc
```

```
disp("The rate of change of inductance with
   deflection is,")
disp("dL/d(theta)=d(12+6(theta)-(theta^2))/d(theta)
   =6-2(theta) uH/radian= 6-2(theta)*10^-6 H/radians
   ")
disp("From the torque equation,")
disp("theta=(I^2)dL/(2*K*d(theta))")
disp("therefore, theta=(8^2)*[6-2(theta)]*10^-6
   /(2*12*10^-6)")
disp("Therefore, 0.375(theta)=6-2(theta)")
t=6/2.375
format(6)
disp(t,"Therefore, theta[in radians]= ")
```

Scilab code Exa 6.3 shunt resistance

```
//example6.3
clc
disp("Given values are, (R_m)=100 ohm, (I_m)=2 mA, I
   =150 mA")
disp("(R_sh)=[(I_m)*(R_m)]/[I-(I_m)]")
r=(2*100*10^-3)/((150*10^-3)-(2*10^-3))
format(6)
disp(r,"Therefore, (R_sh)[in ohm]=(2*100*10^-3)
   /((150*10^-3)-(2*10^3))=")
```

Scilab code Exa 6.4 current through shunt and resistance of motor

```
//example6.4
clc
disp("a) The drop across the shunt is same as drop
   across the coil.")
disp("Therefore, [(I_sh)*(R_sh)]=400 mV")
```

```
i=(400*10^-3)/0.01
disp(i,"Therefore, I_sh(in A)=(400*10^-3)/0.01= ")
disp("b) The voltage across shunt for shunted
   current of 50 A is,")
v=50*0.01
disp(v,"V_sh(in V)=[(I_sh)*(R_sh)]=50*0.01=")
disp("For this voltage the meter should give full
   scale deflection. In first case, the current
   through meter for full deflection was,")
i=(400*10^-3)/750
disp(i,"I_m(in A)=(400mV)/(R_m)=(400*10^-3)/750=")
disp("The same I_m must flow for new voltage across
   the meter of 0.5 V")
disp("Therefore, [(I_m)*(R_m)'']=0.5")
disp("Therefore, [(5.33*10^-4)*(R_m)'']=0.5")
r=0.5/(5.33*10^-4)
disp(r,"Therefore, (R_m'')[in ohm]=")
disp("This is the resistance of the meter required
   for 50 A shunted current to give full scale
   defection.")
```

Scilab code Exa 6.5 multiplier resistance

```
//example6.5
clc
disp("Given values are, R_m=500 ohm, I_m=40 uA and V
   =10 V")
r=(10/(40*10^-6))-500
format(8)
disp(r,"Now, (R_s)[in ohm]=V/(I_m) - R_m =")
disp("This is the required multiplier resistance")
```

Scilab code Exa 6.6 shunt required and multiplier required

```
//example6.6
clc
disp("The meter current (I_m)=20 mA")
disp("Drop across meter, (V_m)=200 mV")
disp("Now, (V_m)=[(I_m)*(R_m)]")
disp("Therefore, 200 mV = (20 mA)(R_m)")
r=200/20
disp(r,"Therefore, (R_m)[in ohm]=")
disp("i) For using it as an ammeter, I=200 A")
r=(200*10^-3)/(200-(20*20^-3))
format(6)
disp(r,"R_sh(in ohm)=[(I_m)*(R_m)]/[I-(I_m)]=")
disp("This is the required shunt.")
disp("ii) For using it as a voltmeter, V=500 V")
disp("Therefore, (R_s)=V/(I_m) - (R_m)")
r=(500/(20*10^-3))-10
format(8)
disp(r,"= (500/(20*10^-3))-10 = ")
disp("This is the required multiplier.")
```

Scilab code Exa 6.7 voltage induced

```
//example6.7
clc
disp("The arrangement is shown in the Fig 6.18(a)")
disp("The voltmeter range = 50 V")
r=100*50
disp(r,"Therefore, (R_m)[in ohm] = Voltmeter resistance = 100 ohm/V * 50 =")
disp("This appears in parallel with 55 ohm resistor as shown in the Fig.6.18(b)")
r=(55*5000)/(55+5000)
format(9)
disp(r,"Therefore, R'' (in ohm)= 55||5000 = (55*5000)/(55+5000)= ")
```

```
i=80/(105+54.40158)
format(8)
disp(i,"Therefore, I(in A)=80/(105+R'')=")
v=0.501877*54.40158
disp(v,"Therefore, Voltage across R''(in V)=[I*R
    '']=0.501877*54.40158=")
disp("The voltmeter will sense this voltage.")
disp("Therefore, Voltage indicated = 27.3029 V")
```

Scilab code Exa 6.8 resistance

```
//example6.8
clc
disp("I_m=15 mA, R_m=5 ohm")
disp("i) I=2A")
r=(15*5*10^-3)/(2-(15*10^-3))
format(8)
disp(r,"R_sh(in ohm)=[(I_m)*(R_m)]/[I-(I_m)]=")
disp("ii) V=100 V")
r=(100/(15*10^-3))-5
format(10)
disp(r,"R_s(in ohm)=V/I_m - R_m =")
```

Scilab code Exa 6.9 ammeter and voltmeter

```
//example6.9
clc
disp("R_m=5 ohm, I_m=15 mA")
disp("i) I=15A")
r=(15*5*10^-3)/(15-(15*10^-3))
format(9)
disp(r,"R_sh(in ohm)=[(I_m)*(R_m)]/[I-(I_m)]=")
disp("ii) V=15 V")
```

```
r=(15/(15*10^-3))-5
format(4)
disp(r,"R_s(in ohm)=V/I_m - R_m =")
```

Scilab code Exa 6.10 number of turns

```
//example6.10
clc
disp("R_m=2000 ohm, V_m=100 V, N=10000")
i=100/2000
disp(i,"Therefore, I_m(in A)=(V_m)/(R_m)=100/2000=")
i=0.05*10000
disp(i,"Therefore, AT for full scale deflection = (I_m)*N=0.05*10000")
disp("For I=20 A, AT=I*N''")
disp("Therefore, 500=20*N''")
n=500/20
disp(n,"Therefore, N''=")
```

Scilab code Exa 6.11 shunt resistance and full scale deflection

```
//example6.11
clc
disp("I_m=15 mA, R_m=1.5 ohm at 15 degree celcius, R=3.5 ohm")
r=1.5+3.5
disp(r,"Therefore, R_mT(in ohm)= Total meter resistance = 1.5+3.5 = ")
disp("i) I=20A")
r=(15*5*10^-3)/(20-(15*10^-3))
format(10)
disp(r,"Therefore, R_sh(in ohm)=[(I_m)*(R_mT)]/[I-(I_m)]=")
```

```
disp(" ii ) V=250 V")
r=(100/(15*10^-3))-5
disp(r," R_s(in ohm)=V/I_m - R_mT =")
disp("Now at 25 degree celcius , (R_m)'' is the new
    meter resistance.")
disp("R_m'' = R_m[1+(alpha_1)*(t2-t1)] where t1=15
    degree celcius , t2=25 degree celcius")
a=(1/234.5)/(1+(15/234.5))
format(6)
disp(a," (alpha_1)[in per degree celcius]=(alpha_0)
    /(1+[(alpha_0)*t1])=(1/234.5)/(1+(15/234.5))=")
r=1.5*(1+(0.004*(25-15)))
format(8)
disp(r," Therefore , R_m''(in ohm)
    =1.5*(1+(0.004*(25-15)))= ")
r=1.56012+3.5
format(8)
disp(r," Therefore , R_mT''(in ohm)=1.56012+3.5=")
disp(" Error in part(i) : The Fig. 6.19 shows two
    cases.")
disp(" Therefore , I_m1 at 15 degree celcius = (I*R_sh
    )/[(R_sh+(R_mT))]=7.4999*10^-4 I")
disp(" Therefore , I_m2 at 25 degree celcius = (I*R_sh
    )/[(R_sh+(R_mT''))]=7.41092*10^-4 I")
i=((7.41092*10^-2)-(7.4999*10^-2))/(7.4999*10^-4)
format(7)
disp(i,"% error = [(I_m2)-(I_m1)*100]/(I_m1)= ")
disp(" Negative sign indicates that the reading is
    less than the actual reading.")
disp(" Error in part(ii) : The Fig. 6.19 shows two
    cases.")
disp(" Therefore , V_m1 = (V*R_mT)/(R_mT+R_s)=(5*V)
    /(5+16661.67)=2.9999*10^-4 V")
disp(" Therefore , V_m2 = (V*R_mT'')/(R_mT''+R_s)
    =(5.06012*V)/(5.06012+16661.67)=3.03606*10^-4 V")
v=((3.03606*10^-2)-(2.9999*10^-2))/(2.9999*10^-4)
format(7)
disp(v,"% error = [(V_m2)-(V_m1)*100]/(V_m1)= ")
```

Chapter 7

Semiconductor Physics and Diode

Scilab code Exa 7.1 forbidden gap

```
//Example 7.1
clc
disp("Forbidden gap for silicon is given by,")
disp("E_C = 1.21 - 3.6*10^-4 * T")
disp("Now  T = 35+273 = 308 K")
ec=1.21-(308*3.6*10^-4)
format(6)
disp(ec,"Therefore,  E_C(in eV) =")
disp("While forbidden gap for germanium is given by,
  ")
disp("E_C = 0.785 - 2.23*10^-4 * T")
ec=0.785-(308*2.23*10^-4)
format(7)
disp(ec,"Therefore,  E_C(in eV) =")
```

Scilab code Exa 7.2 resistivity

```
//Example 7.2
clc
disp("The given values are, n_i = 1.5*10^10 / cm^3")
disp("Therefore, n_i = 1.5*10^10/10^-6 /m^3")
disp("                  = 1.5*10^16 /m^3")
disp("And  u_n = 1300*10^-4 m^2/V-sec")
disp("     u_p = 500*10^-4 m^2/V-sec")
disp("Now  sigma_i = n_i*(u_n + u_p)*e
   ...conductivity")
sig=(1.5*10^16)*(1300+500)*(1.6*10^-23)
format(9)
disp(sig,"Therefore  sigma_i(in per ohm-m) =")
rho=1/0.000432
format(10)
disp(rho,"Therefore,  rho(in ohm-m) = 1/sigma_i =")
disp("This is the required resistivity")
```

Scilab code Exa 7.3 current in the bar

```
//Example 7.3
clc
disp("Electron density = n_i = carrier intrinsic
   concentration")
disp("Therefore,  n_i = 1.5*10^16 /m^3")
disp("For intrinsic semiconductor,")
disp("  sigma_i = n_i*(u_n + u_p)*e")
disp("where  e = charge on one electron = 1.6*10^-19
   C")
sig=(1.5*10^16)*(0.14+0.05)*(1.6*10^-19)
format(9)
disp(sig,"Therefore  sigma_i(in per ohm-m) =
   Conductivity =")
rho=1/0.000456
format(9)
disp(rho,"Therefore,  rho(in ohm-m) = Resistivity =
```

```
   1/sigma_i =")
disp("        Now     R = roh*l/A")
disp("Therefore,  V/A = roh*l/A")
l=((9*2.5*10^-4)/(2192.982*1.2*10^-3))*10^3
format(6)
disp(l,"Therefore,  l(in mm) =")
disp("This is the length of the bar")
```

Scilab code Exa 7.4 resistivity of intrinsic germanium

```
//Example 7.4
clc
disp("Given values are")
disp("   n_i = 2.5*10^13 /cm^3")
disp("Therefore,   n_i = 2.5*10^13/10^-6 /m^3")
disp("                 = 2.5*10^19 /m^3")
disp("And   u_n = 3800*10^-4 m^2/V-sec")
disp("      u_p = 1800*10^-4 m^2/V-sec")
disp("   sigma_i = n_i*(u_n + u_p)*e")
sig=(2.5*10^19)*(3800+1800)*(1.6*10^-23)
format(5)
disp(sig,"Therefore  sigma_i(in per ohm-m) =")
rho=1/2.24
format(7)
disp(rho,"Therefore,  rho_i(in ohm-cm) = 1/sigma_i =
   ")
```

Scilab code Exa 7.7 comparing two values

```
//Example 7.7
clc
disp("Referring to the table 7.2 of properties of
   germanium has 4.4*10^22 atoms/cm^3")
```

```
disp("For 10^8 germanium atom there is 1 atom
   impurity added, as given.")
disp("Thus, for 4.4*10^22 germanium atoms, we have,"
   )
disp("        = 4.4*10^22 / 10^8 = 4.4*10^14 atoms of
    impurity/cm^3")
disp("This is nothing but concentration of donor
   atoms i.e. N_D")
disp("Therefore,  N_D = 4.4*10^14 per cm^3 =
   4.4*10^14/10^-6 = 4.4*10^20 per m^3")
disp("Now as donor impurity is added, n-type
   material will form,")
disp("Therefore,  sigma_n = n_n*u_n*q = N_D*u_n*q")
disp("where  n_n ~ N_D and u_n = 3800 cm^2/V-sec =
   3800*10^-4 m^2/V-sec")
sigm=4.4*3800*1.6*10^-3
format(7)
disp(sigm,"Therefore,  sigma_n(in per ohm-m) =")
rho=(1/26.752)*10^2
format(5)
disp(rho,"Therefore,  rho_n(in ohm-cm) = Resistivity
    = 1/sigma_i =")
disp("Comparing this with resistivity of intrinsic
   germanium it can be observed that resistivity
   reduces considerably due to addition of impurity.
    Hence conductivity of n-type material is much
   higher and hence it can carry more current as
   compared to the intrinsic semiconductors. By
   controlling amount of doping we can control the
   conductivity.")
```

Scilab code Exa 7.9 new diode current

```
//Example 7.9
clc
```

```
disp("The current equation of a diode is")
disp("I = I_0 * (e^(V/eta*VT) - 1)")
disp("At 300 K,  VT = 26 mV = 26*10^-3 V")
disp("  V = 0.71 V for I = 2.5 mA  and eta = 2 for silicon")
i0=(2.5*10^-3)/((%e^(0.71/(2*26*10^-3)))-1)
format(9)
disp(i0,"Therefore,  I_0(in A) =")
disp("Now V = 0.8 V")
i=((2.93*10^-9)*((%e^(0.8/(2*26*10^-3)))-1))*10^3
format(6)
disp(i,"Therefore,  I(in mA) =")
```

Scilab code Exa 7.10 forward bias current

```
//Example 7.10
clc
disp("the given values are I_0 = 3 uA, T = 27 C = 27+273 = 300 K, eta =1")
disp("Now  I_rated = 1 A for diode")
disp("and  I = 1% of I_rated at 27 C")
disp("Therefore,  I = 0.01 A")
vt=300*8.62*10^-5
format(6)
disp(vt,"V_T(in V) = k*T =")
disp("According to diode equation,  I = I_0 * (e^(V/eta*VT) - 1)")
v=8.112*0.026
format(7)
disp(v,"Therefore,  V(in V) =")
```

Scilab code Exa 7.11 reverse saturation current and eta for diode

```
//Example 7.11
clc
disp("At V1 = 0.4 V, I1 = 10 mA and at V2 = 0.42 V, I2 = 2*I1 = 20 mA")
disp("Now  I = I_0 * (e^(V/eta*VT) - 1)")
disp("Therefore,  (10*10^-3) = I_0 * (e^(0.4/(eta*26*10^3)) - 1)            ...(1)")
disp("and  (20*10^-3) = I_0 * (e^(0.42/(eta*26*10^3)) - 1)                  ...(2)")
disp("In forward bias condition 1 << e^(VT/eta*VT),  Therefore, Neglecting 1")
disp("(10*10^-3) = (I_0)*e^(15.384/eta)      ..(3)")
disp("and, (20*10^-3) = (I_0)*e^(16.153/eta)")
disp("Dividing the two equations (3) and (4),")
disp("(1/2) = (e^(15.384/eta))/(e^(16.153/eta))")
disp("Therefore, (e^(16.153/eta)) = 2*(e^(15.384/eta))")
disp("Taking natural logarithm of both sides,")
disp("Therefore, 16.153/eta = ln2 + 15.384/eta")
disp("Therefore, (1/eta)*(16.153-15.384) = 0.6931")
e=(16.153-15.384)/0.6931
disp(e,"Therefore, eta=")
disp("Hence (I_0)=9.45 nA")
```

Scilab code Exa 7.12 reverse saturation current and forward current

```
//Example 7.12
clc
disp("I_01 = 3 nA at T1 = 27 C, T2 = 82 C")
dt=82-27
format(3)
disp(dt,"(i) deltaT(in degree C) = T2 - T1 =")
dt1=(2^(55/10))*3
format(8)
disp(dt1,"Therefore,  I_02(in nA) = 2^(deltaT/10) *
```

```
I_01 =")
disp("(ii) V = 0.25 V, I_02 = 135.764 nA at 82 C")
disp("Thereforem  I_f = I_0 * (e^(V/eta*VT) - 1)")
vt=(82+273)/11600
format(7)
disp(vt,"V_T(in V) = T/11600 =")
disp("eta = 2 for Si")
i0=((135.764*10^-9)*((%e^(0.25/(2*0.0306)))-1))*10^6
format(6)
disp(i0,"Therefore,  I_f(in uA) =")
```

Scilab code Exa 7.14 dc output voltage

```
//Example 7.14
clc
disp("In the circuit of the fig.7.47(a), the diode
   will be forward biased during negative half cycle
    of a.c. input voltage, and d.c output voltage
   will be negative w.r.t common ground terminal, as
    shown.")
disp("(a) For an ideal diode, cut-in voltage V_T =
   0, R_T = 0")
dc=-(15/%pi)
format(5)
disp(dc,"D.C. output voltage(in V) = -Maximum value
   of a.c. input voltage / pi =")
disp("Negative sign indicates that voltage is
   negative w.r.t ground.")
disp("(b) For a silicon diode, V_T = 0.7 V, R_f is
   assumed to be zero")
dc1=-((15-0.7)/%pi)
format(5)
disp(dc1,"D.C. output voltage(in V) = -[Maximum
   value of a.c. voltage-V_T] / pi =")
```

Scilab code Exa 7.15 dc voltage and load current

```
//Example 7.15
clc
disp("Given values are R_L = 1 k-ohm, V_m = 10 V peak")
disp("case(i) Ideal diode")
disp("Cut-in voltage V_T = 0 V, R_f = 0 ohm")
edc=10/%pi
format(5)
disp(edc,"Therefore, E_DC(in V) = V_m/pi =")
idc=3.18
disp(idc,"Therefore, I_DC(in mA) = E_DC/R_L =")
disp("case(ii) Silicon diode")
disp("Cut-in voltage V_T = 0.7 V")
edc=9.3/%pi
format(5)
disp(edc,"Therefore, E_DC(in V) = V_m-V_T / pi =")
idc=2.96
disp(idc,"Therefore, I_DC(in mA) = E_DC/R_L =")
```

Scilab code Exa 7.17 power to load and regulation and efficiency and TUF of secondary

```
//example7.17
clc
disp("Given: E_s=30 V, R_f=2 ohm, R_s=8 ohm, R_L=1 k-ohm")
disp("E_s=E_RMS=30 V")
e=30*sqrt(2)
disp(7)
disp(e,"E_sm(in V)=(E_s)*sqrt(2)=")
```

```
i=(30*sqrt(2))/(2+1000+8)
format(6)
disp(i,"I_m(in A)=(E_sm)/(R_f+R_L+R_s)=")
i=(2*42)/(%pi)
format(6)
disp(i,"I_DC(in mA)=(2*I_m)/pi=")
p=1000*(26.74*10^-3)^2
disp(p,"a) Power delivered to the load = (I_DC^2)*(
    R_L) = ")
v=(2*30*sqrt(2))/(%pi)
format(3)
disp(v,"V_DC, no load = (2*E_sm)/pi = ")
v=26.74*1000*10^-3
format(6)
disp(v,"V_DC, full load (in V) = (I_DC)*R_L = ")
r=((27-26.74))/26.74
format(5)
disp(r,"% Regulation = ((V_NL-V_FL)*100)/(V_FL)= ")
e=(8/(%pi)^2)*(1/(1+(10/1000)))
format(6)
disp(e,"c) Efficiency of rectification = dc output/
    ac output =")
t=(30*42*10^-3)/sqrt(2)
format(5)
disp(t,"d) Transformer secondary rating(in W) = (
    E_RMS)*(I_RMS) = ")
u=0.715/0.89
disp(u,"TUF = DC power output/AC rating = ")
```

Scilab code Exa 7.20 ac input power

```
//example7.20
clc
disp("P_DC=500 W, Half wave rectifier")
disp("For half wave rectifier, %eta=40.6%          ...(
```

```
Assuming maximum)")
disp("Therefore, 40.6=(P_DC*100)/(P_AC)")
disp("Therefore, 40.6=(500*100)/(P_AC)")
p=(500*100)/(40.6)
format(9)
disp(p,"Therefore, P_AC(in W)=")
disp("For the same load, with full wave rectifier the maximum rectifier efficiency is 81.2%")
disp("Therefore, 81.2=(500*100)/(P_AC)")
p=(500*100)/81.2
format(10)
disp(p,"Therefore, P_AC(in W)=")
```

Scilab code Exa 7.21 percentage eta

```
//example7.21
clc
disp("The given values are,")
disp("R_f=0.1 ohm, I_DC=10 A, R_s= 0 ohm, E_s(RMS)=30 V")
e=30*sqrt(2)
format(8)
disp(e,"Now, (E_sm)=E_sm(RMS)*sqrt(2) =")
disp("(I_DC)=(2*I_m)/pi")
i=(%pi*10)/2
disp(i,"I_m(in A)=(pi*I_DC)/2=")
disp("Now, (I_m)=(E_m)/(2*R_f+R_s+R_L)")
disp("Therefore, 15.7079 = 42.4264/(2*0.1+R_L)")
disp("Therefore, R_L+0.2=2.7")
r=2.7-0.2
disp(r,"Therefore, R_L(in ohm)=")
p=(10^2)*2.5
disp(p,"P_DC(in W)=(I_DC^2)*R_L=")
disp("P_AC = (I_RMS^2)*(2*R_f+R_s+R_L)")
i=15.7079/sqrt(2)
```

```
disp(i,"and, (I_RMS)[in A]=(I_m)/sqrt(2)=")
p=(11.1071^2)*(0.2+2.5)
disp(p,"Therefore, (P_AC)[in W]=")
e=(250*100)/333.092
disp(e,"% eta=(P_DC*100)/(P_AC)=")
```

Scilab code Exa 7.22 dc load current and load voltage and ripple voltage and PIV rating

```
//example7.22
clc
disp("R_L =5 k-ohm=5*10^3 ohm, N1:N2 is 2:1")
disp("E_p = 460V RMS value")
disp("Therefore, (E_s)/(E_p)=N2/N1=1/2")
disp("Therefore, E_s = (E_p)/2 = 230 V")
e=230*sqrt(2)
format(8)
disp(e,"Therefore, E_sm(in V)=")
disp("Now, (I_DC)=(2*I_m)/pi          where (I_m)=(E_sm)/(R_L) neglecting R_f")
i=(2*325.269)/(%pi*5*10^3)
format(8)
disp(i,"Therefore, (I_DC)[in A]=(2*E_sm)/(pi*R_L)=")
d=41.41*5
format(8)
disp(d,"DC load voltage E_DC(in V) = (I_DC)*(R_L) = ")
disp("Ripple voltage = ripple factor*(V_DC)")
disp("Ripple factor of bridge rectifier is 0.482")
r=0.482*207.072
format(5)
disp(r,"Therefore, Ripple factor = ")
disp("PIV rating of each diode = (E_sm) for bridge rectifier = 325.27 V")
```

Scilab code Exa 7.23 load voltage and ripple voltage

```
//exmaple7.23
clc
disp("E_p(rms) = 230V, N2/N1 = 1/15, R_L=50 ohm")
disp("R_f = R_s = 0 ohm as ideal")
disp("Now, E_p(rms)/E_s(rms) = N1/N2")
e=230/15
format(7)
disp(e,"Therefore, E_s(rms)[in V] = N2*E_p(rms)/N1 =
    230/15 = ")
e=15.333*sqrt(2)
disp(e,"Therefore, E_sm(in V) = ")
i=21.684/50
disp(i,"Therefore, (I_m) = (E_sm)/(R_s+2*R_f+R_L)= "
    )
i=(2*0.4336)/(%pi)
disp(i,"I_DC(in A)=(2*I_m)/pi=")
e=0.276*50
disp(e,"Therefore, E_DC(in V)=Load voltage=(I_DC)*(
    R_L)=")
disp("Ripple factor = 0.482        ..For full wave
    rectifier")
disp("Ripple factor = (ac rms output)/(dc output)=(
    ripple voltage)/E_DC")
disp("Therefore, 0.482=ripple factor")
r=13.8*0.482
disp(r,"Therefore, Ripple voltage = 13.8*0.482 = ")
```

Scilab code Exa 7.25 dc output voltage

```
//example7.25
```

```
clc
disp("For a half wave rectifier ,")
disp("(I_m) = (E_sm)/(R_f+R_L)")
disp("and, (I_DC) = (I_m)/pi = (E_sm)/pi*(R_f+R_L)")
disp("and, (V_DC) = (I_DC)*(R_L)")
disp("Therefore, (P_DC) = (V_DC)*(I_DC) = (I_DC^2)*(R_L) = ((E_sm^2)*(R_L))/((pi^2)*(R_f+R_L)^2)")
disp("For this power to be maximum,")
disp("(dP_DC)/(dR_L) = 0")
disp("(d/dR_L)*((E_sm^2)*(R_L))/((pi^2)*(R_f+R_L)^2) = ((E_sm^2)/(pi^2))*((R_f+R_L)^2 - R_L*2(R_f+R_L))/(R_f+R_L)^4")
disp("Therefore, (R_f+R_L)^2 - 2*R_L*(R_f+R_L) = 0")
disp("Therefore, (R_f^2)-(R_L^2) = 0")
disp("Therefore, (R_L)^2 = (R_f)^2     i.e.     R_L = R_f")
disp("Thus the power output is maximum if R_L = R_f")
```

Scilab code Exa 7.29 forward current

```
//example7.29
clc
disp("For silicon diode, eta=2, (I_0)=10 uA, (V_T)=26 mV")
disp("I = (I_0)*[e^(V/(eta*V_T))-1]")
i=(10*10^-6)*(%e^(0.1/(2*26*10^-3))-1)
format(13)
disp(i,"i) I(in A)=(10*10^-6)*(e^(0.1/(2*26*10^-3))-1)=")
i=(10*10^-6)*(%e^(0.2/(2*26*10^-3))-1)
disp(i,"ii) I(in A)=(10*10^-6)*(e^(0.1/(2*26*10^-3))-1)=")
i=(10*10^-6)*(%e^(0.3/(2*26*10^-3))-1)
```

```
disp(i,"iii) I(in A)=(10*10^-6)*(e^(0.1/(2*26*10^-3))-1)=")
```

Scilab code Exa 7.30 temperature

```
//example7.30
clc
disp("(I_01)=0.1 uA, (T_1)=20 degree celcius, (T_2)=40 degree celcius")
i=(0.1)*(2^(20/10))
disp(i,"Therefore, (I_02)[in uA]=(I_01)*(2^(delta(T))/10)")
```

Scilab code Exa 7.31 conductivity of silicon

```
//example7.31
clc
disp("As the impurity is accepter, it forms a p-type material.")
disp("Therefore, N_A = 10^22 /m^3 = p_p")
disp("Now, (p_p)*(n_p)=(n_i)^2    i.e.   (10^22)*(n_p)=(1.4*10^16)^2")
n=((1.4*10^16)^2)/(10^22)
disp(n,"Therefore, n(in /m^3)= ")
r=((1.96*0.145*10^10)+(0.05*10^22))*(1.6*10^-19)
disp(r,"rho(in (ohm-m)^-1) = ((n_p*u_n)+(p_p*u_p))*e = ")
```

Chapter 8

Transistors

Scilab code Exa 8.1 base current

```
//exmaple8.1
clc
disp("Given : I_E=12 mA, I_E= 1.02(I_c)")
disp("Therefore , 1.02(I_c)=12*10^-3")
i=(12*10^-3)/1.02
format(9)
disp(i,"I_c(in A)=")
disp("I_E = I_B + I_c")
b=12-11.765
disp(b,"Therefore , I_B(in mA) = I_E - I_c =
    (12-11.765)mA = ")
```

Scilab code Exa 8.2 alpha dc and beta dc

```
//example8.2
clc
disp("a) (alpha_dc)=(beta_dc)/(1+(beta_dc))")
b=50/51
```

```
format(7)
disp(b,"For, (beta_dc)=50, (alpha_dc)=50/(1+50)=")
b=190/191
disp(b,"For, (beta_dc)=190, (alpha_dc)=190/(1+190)=")
disp("b) (beta_dc)=(alpha_dc)/(1-(alpha_dc))")
a=0.995/(1-0.995)
disp(a,"For, (alpha_dc)=0.995, (beta_dc)=0.995/(1-0.995)=")
a=0.9765/(1-0.9765)
format(6)
disp(a,"For, (alpha_dc)=0.9765, (beta_dc)=0.9765/(1-0.9765)=")
```

Scilab code Exa 8.3 collector current

```
//example8.3
clc
disp("Given : I_B=20 uA, I_E=6.4 mA")
disp("I_E=I_B+I_C=I_B+[(I_B)*(beta_dc)]=(I_B)*(1+(beta_dc))")
b=(6.4*10^-3)/(20*20^-6)
disp(b,"(beta_dc)+1=(I_E)/(I_B)=")
b=320-1
disp(b,"Therefore, (beta_dc)=")
a=319/320
format(7)
disp(a,"(alpha_dc)=(beta_dc)/(1+(beta_dc))=319/(1+319)=")
i=319*20
disp(i,"I_C(in uA)=[(beta_dc)*(I_B)]=")
c=0.9968*6.4
disp(c,"Also, (I_C)[in mA]=[(alpha_dc)*(I_E)]=")
```

Scilab code Exa 8.4 alpha dc and beta dc

```
//example8.4
clc
disp("Given: I_CO=1.1 uA, I_E=21 uA")
disp("I_CEO=(1+(beta_dc))*(I_CO)")
disp("1+(beta_dc)=(I_CEO).(I_CO)=(21 uA)/(1.1 uA)=19")
b=19-1
disp(b,"Therefore, (beta_dc)=")
a=18/19
format(6)
disp(a,"(alpha_dc)=(beta_dc)/(1+(beta_dc))=18/(1+18)=")
```

Scilab code Exa 8.7 alpha and beta and V0 and output power

```
//example8.7
clc
disp("V_m= Peak value of input =200 V")
disp("V_BO=100 V with I_G=2 mA and R_L=100 ohm")
a=asind(1/2)
disp(a,"i) Firing angle alpha(in degree)=sinh((V_BO)/(V_m))=sinh(100/200)=")
a=180-30
disp(a,"ii) Conduction angle beta = 180-(alpha) =")
v=(200*(1+cosd(30)))/(2*%pi)
format(7)
disp(v,"iii) Average output voltage (V_dc)=(V_m*(1+cos30))/(2*pi)=")
p=(59.39^2)/100
format(8)
```

```
disp(p,"(P_dc(av))[in W]=(V_dc^2)/R_L=")
```

Scilab code Exa 8.8 firing angle

```
//example8.8
clc
disp("(V_dc(av))=80 V, (V_rms)=230 V")
disp("Note that given ac mains voltage is rms unless and otherwise specified to be peak")
v=230*sqrt(2)
format(8)
disp(v,"Therefore, V_m(in V)=sqrt(2)*(V_rms)=")
disp("Now , (V_dc(av))=(V_m*(1+cos(alpha)))/(2*pi)")
disp("Therefore, 80=(325.269*(1+cos(alpha)))/(2*pi)")
disp("Therefore, cos(alpha)=0.5453")
c=acosd(0.5453)
format(6)
disp(c,"Therefore, alpha(in degree)=")
```

Scilab code Exa 8.9 time for SCR remains off

```
//example8.9
clc
disp("For half wave rectifier, the SCR operates as shown in the Fig. 8.63.")
disp("V_in = 325*sin(wt)=V_m*sin(wt)")
disp("Therefore, V_m = 325 V")
disp("w=100*pi rad/sec")
disp("V_BO=125 V")
a=sinh(125/325)
format(6)
disp(a,"Therefore, alpha=sinh(V_BO/V_m)=")
```

```
d=(22.619*%pi)/180
format(7)
disp(d,"Therefore , alpha=(22.619*pi)/180 radian=")
t=0.3947/(100*%pi)
format(8)
disp(t,"Therefore , Time of alpha(in sec)=alpha/w
    =0.3947/(100*pi)=")
disp("For this period SCR remains OFF in positive
    half cycle.")
disp("While for entire negative half cycle i.e. for
    pi radians (180 degree) it remains OFF. Thus
    corresponding time is (angle/w)")
a=1/100
disp(a,"i.e. pi/(100*pi)[in sec]= ")
t=10+1.25
disp(t,"Total time for which SCR is OFF(in msec) =
    10+1.25= ")
```

Chapter 9

Cathode Ray Oscilloscope

Scilab code Exa 9.1 time for electon

```
//example9.1
clc
disp("The arrangement is shown in the Fig. 9.2")
disp("Let x=0 at negative plate and x=2*10^-2 m at
    positive plate.")
disp("The E is constant and its magnitude is given
    by,")
e=10/(2*10^-2)
disp(e,"E(in V/m)=V/d=")
disp("The electron will move with constant
    acceleration as field is uniform,")
a=(1.6*500*10^-19)/(9.107*10^-13)
disp(a,"a_x(in m/sec^2)=(q*E)/m=")
disp("The velocity v_x is given by,")
disp("(v_x)=(a_x)*t+(V_ox)        .. v_ox =0 as
    electron is at rest")
disp("and  x=(1/2 *a_x *t^2)+(V_ox *t)+(x_o)....(
    v_ox)=(x_o)=0")
x=(1/2)*8.7844*(10^13)*((1*10^-9)^2)
disp(x,"Therefore, x(in m)=(1/2)*8.7844*(10^13)
    *((1*10^-9)^2)=")
```

```
disp("ii) When electron reaches to second plate, x=2*10^-2 m")
disp("Therefore, x=(1/2)*(a_x)*t^2")
disp("Therefore, 2*10^-2 = (1/2)*(8.7844*10^13)*t^2")
disp("Therefore, t^2 = 4.5535*10^-16")
t=sqrt(4.5535*10^-16)
format(15)
disp(t,"Therefore, t(in sec)=")
```

Scilab code Exa 9.2 final velocity pf electron

```
//example9.2
clc
disp("Initially electron is at rest and V=200 V")
disp("Therefore, v(in m/sec)=sqrt(2*q*V/m)=(5.94*10^5)*sqrt(V)")
v=(5.94*10^5)*sqrt(200)
format(8)
disp(v,"= (5.94*10^5)*sqrt(200) = ")
```

Scilab code Exa 9.4 velocity and deflection and deflection sensitivity

```
//example9.4
clc
disp("d=1 cm, L=33 cm, l=4.5 cm, (V_a)=300 V, (V_d)=50 V")
v=sqrt((2*1.6*300*10^-19)/(9.107*10^-31))
format(9)
disp(v,"i) (v_ox[in m/s])=sqrt(2*q*(V_a)/m)=sqrt((2*1.6*300*10^-19)/(9.107*10^-13))=")
d=((4.5*10^-2)*(33*10^-2)*50)/(2*300*10^-2)
format(7)
```

```
disp(d,"ii) D(in m)=(l*L*(V_d))/(2*d*V_a)= ")
s=0.1237/50
format(9)
disp(s,"iii) S(in m/V)=D/(V_d)= ")
```

Scilab code Exa 9.7 speed of electron and force on electron

```
//exmaple9.7
clc
disp("phi=8 degree , l=3 cm, B=0.6 mT=0.6*10^-3 Wb/m^2")
disp("a) phi=(l*q*B)/(m*v) where v= velocity of electrons")
disp("But phi must be in radians")
p=(8*%pi)/180
format(7)
disp(p,"Therefore , phi=8 degree=(8*pi)/180 radians=")
disp("Therefore , 0.1396 = ((3*10^-2)*(1.6*10^-19)*(0.6*10^-3))/(9.107*10^-31 *v)")
v=((3*10^-2)*(1.6*10^-19)*(0.6*10^-3))/(0.1396*9.107*10^-31)
format(9)
disp(v,"Therefore , v(in m/s)=")
disp("b) f_m(in N) = (B*q*v) = force on each electron")
f=(0.6*10^-3)*(1.6*10^-19)*(22.65*10^6)
disp(f,"= (0.6*10^-3)*(1.6*10^-19)*(22.65*10^6) = ")
```

Scilab code Exa 9.8 amplitude and rms value

```
//example9.8
clc
```

```
disp("It can be observed that the screen is divided
   such that one part is subdivided into 5 units.")
disp("Therefore, 1 subdivision = 1/5 = 0.2 units")
disp("It can be observed that positive peak of
   signal corresponds to two full divisions and
   three subdivisions. Hence positive peak is
   2+3*0.2=2.6 units while the negative peak also
   corresponds to 2.6 units.")
v=2.6+2.6
disp(v,"Therefore, (V_pp)[in divisions]=Peak to peak
   =2.6+2.6=")
v=5.2*2*10^-3
disp(v,"Therefore, (V_pp)[in V]=Number of divisions*
   volts/divisions= ")
a=10.4/2
disp(a,"Therefore, (V_m)[in mV]=Amplitude=(V_pp)/2="
   )
v=5.2/(sqrt(2))
format(8)
disp(v,"and, (V_RMS)[in mV]= (V_m)/sqrt(2)= ")
```

Scilab code Exa 9.10 phase difference

```
//example9.10
clc
disp("It can be observed from the Lissajous figures
   that,")
disp("(y_1)=8 units       and,      (y_2)=10 units")
s=asind(8/10)
format(6)
disp(s,"Therefore, phi (in degree)= asind((y_1)/(y_2
   ))=asind(8/10)=")
```

Scilab code Exa 9.11 unknown frequency of vertical signal

```
//example9.11
clc
disp("It can be observed that,")
disp("Number of vertical tangencies = 2")
disp("Number of horizontal tangencies = 5")
disp("Now, (f_v/f_H) = 5/2")
disp("Therefore, f_v = 5/2")
disp("f_H = 5/2 * 1 kHz")
f=5/2
disp(f,"Therefore, f_v(in kHz)=")
disp("This is the unknown frequency.")
```

Scilab code Exa 9.12 deflection sensitivity and angle of deflection and velocity of beam

```
//example9.12
clc
disp("d=0.5 cm, L=20 cm, l=2 cm, (V_a)=1000 V, (V_d)=25 V")
d=((2*10^-2)*(20*10^-2)*25)/(2*0.5*1000*10^-2)
disp(d,"i) D(in m)=(l*L*(V_d))/(2*d*V_a)=")
s=0.01/25
disp(s,"Therefore, S(in m/V)=D/(V_d)=")
disp("ii) tan(theta)=(l*a_y)/(v_ox^2)")
a=((1.6*10^-19)*25)/((0.5*10^-2)*(9.107*10^-31))
format(9)
disp(a,"where, a_y(in m/s^2)=(q*v_d)/(d*m)= ")
v=sqrt((2*1.6*1000*10^-19)/(9.107*10^-31))
disp(v,"v_ox(in m/s)=sqrt((2*q*V_a)/m)=")
t=((2*10^-2)*(8.7844*10^14))/((18.745*10^6)^2)
format(5)
disp(t,"Therefore, tan(theta)=t=((2*10^-2)*(8.7844*10^14))/((18.745*10^6)^2)= ")
```

```
a=atand(0.05)
format(6)
disp(a,"Therefore, theta(in degree)= ")
format(9)
disp(v,"iii) (v_ox)= Velocity of electrons - Velocity of beam =")
```

Scilab code Exa 9.15 time for electron

```
//example9.15
clc
disp("The arrangement is shown in the fig. 9.19")
disp("Negative plate is at x=0")
disp("Therefore, Positive plate is at x=1*10^-2 m")
disp("E=V/d=1000/(1*10^-2)        ...d= 1*10^-2 m")
e=1000/(10^-2)
disp(e,"Therefore, E(in V/m)=")
disp("As field is uniform, the electron will move with constant acceleration.")
disp("Therefore, x = (1/2)*(a_x)*(t^2)")
a=((1.6*10^-19)*(1*10^5))/(9.107*10^-31)
disp(a,"where, a_x(in m/s^2)=(q*E)/m=")
disp("So time for electron to reach positve plate is,")
disp("(t^2)=(2*x)/(a_x)=(2*1*10^-2)/(1.7568*10^16)")
t=sqrt((2*1*10^-2)/(1.7568*10^16))
disp(t,"Therefore, t(in s)=")
```

Scilab code Exa 9.16 deflection sensitivity

```
//example9.16
clc
disp("l=2 cm, d=4 mm, L=25 cm")
```

```
disp("S=D/(V_d)=(l*L)/(2*d*V_a) m/V        ... Defection sensitivity")
disp("i) V_a=1000 V")
s=((2*10^-2)*(25*10^-2))/(2*4*1000*10^-3)
disp(s,"Therefore, S(in m/V)=((2*10^-2)*(25*10^-2))/(2*4*1000*10^-3)= ")
disp("ii) V_a=2000 V")
s=((2*10^-2)*(25*10^-2))/(2*4*2000*10^-3)
disp(s,"Therefore, S(in m/V)=((2*10^-2)*(25*10^-2))/(2*4*2000*10^-3)= ")
disp("iii) V_a=3500 V")
s=((2*10^-2)*(25*10^-2))/(2*4*3500*10^-3)
disp(s,"Therefore, S(in m/V)=((2*10^-2)*(25*10^-2))/(2*4*13500*10^-3)= ")
```

Scilab code Exa 9.17 time taken by electron

```
//example9.17
clc
disp("D=5 mm, V=250V, v_ox=1*10^6 m/s")
e=250/(5*10^-3)
disp(e,"E(in V/m)=V/d=")//answer in text book is wrong
a=((1.6*10^-19)*(50*10^3))/(9.107*10^-31)
disp(a,"a_x(in m/s^2)=(q*E)/m= ")
disp("Now, x= (1/2)*(a_x)*(t^2)+(V_ox)*t+(x_o)  but (x_o)=0 initially")
disp("Therefore, x= (1/2)*(a_x)*(t^2)+(V_ox)*t")
disp("When electron reaches to anode, x=5 mm.")
disp("Therefore, (5*10^-3)=(1/2)*(8.7844*10^15)*(t^2)+(1*10^6)*t")
disp("Therefore, t(in sec)=9.5916D-10        ... neglecting negative value")
disp("Thus time taken by electron to reach anode from cathode is 0.95916 ns.")
```

Scilab code Exa 9.18 input voltage

```
//example9.18
clc
disp("l=2 cm, d=5 mm, L=30 cm, V_a=2000 V, D=3 cm")
disp("D=(l*L*V_d)/(2*d*V_a)")
disp("i.e.  (3*10^-2)=((2*10^-2)*(30*10^-2)*(V_d))
    /((2*5*10^-3)*2000)")
v=((3*10^-2)*(2*5*10^-3)*2000)/((2*10^-2)*(30*10^-2)
    )
disp(v,"Therefore, V_d(in V)=")
disp("But it is applied through amplifier of gain
    100")
g=100/100
disp(g,"Therefore, Input voltage required = (V_d)/
    gain = 100/100 =")
```

Scilab code Exa 9.19 beam velocity and deflection sensitivity and deflection factor

```
//example9.19
clc
disp("l=1.5 cm, d=5 mm, L=50 cm, V_a=2000 V")
v=sqrt((2*2000*1.6*10^-19)/(9.107*10^-31))
disp(v,"1.  v_ox(in m/s)=Beam velocity=sqrt((2*q*V_a
    )/m)=")
s=((1.5*10^-2)*(50*10^-2))/((2*5*10^-3)*2000)
disp(s,"S(in m/V)=D/(V_d)=(l*L)/(2*d*V_a)=")
g=1/(3.75*10^-4)
disp(g,"G(in V/m)=1/S=")
```