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

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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.

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Chapter 1

Electrical Circuits

Scilab code Exa 1.1 obtain the waveform

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

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

Scilab code Exa 1.2 find equivalent resistance

```
1  //example1.2
2  clc
3  disp("Identify  combinations  of  series  and  parallel
       resistances.")
4  disp("The  resistances  5ohm  and  6ohm  are  in  series,
       as  going  to  carry  same  current.")
5  r=5+6
6  disp(r,"So  equivalent  resistance  is (in  ohm)=")
7  disp("While  the  resistances  3ohm,4ohm,4ohm  are  in
       parallel,  as  voltage  across  them  same  but  current
        divides.")
8  r=10/12
9  format(4)
10  disp(r,"(1/R)=(1/3)+(1/4)+(1/5)=")
11  r=12/10
12  disp(r,"Therefore,   R(in  ohm)=")
13  disp("Replacing  these  combinations  redraw  the  fig.
       as  shown  in  the  fig.  1.28(a)")
14  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.")
15  disp("Using  formula  (R1*R2)/(R1+R2)")
16  r=77/18
17  format(6)
18  disp(r,"equivalent  resistance3  is  (11*7)/(11+7)[in
       ohm]=")
19  disp("Replacing  the  respective  combination  redraw
       the  circuit  as  shown  in  the  fig  1.28(b).")
20  disp("Now  3.2  and  4.277  are  in  parallel")
21  r=(3.2*4.277)/(3.2+4.277)
22  format(7)
```

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

Scilab code Exa 1.3 `voltage across three resistances`

```
1  //example1.3
2  clc
3  disp("I=v/(R1+R2+R3)   ..... series circuit")
4  i=60/60
5  disp(i,"I(in amp)=")
6  v=1*10
7  disp(v,"Therefore ,   V_r1(in V)=(I*R1)=(V*R1)/(R1+R2+
       R3)=")
8  v=1*20
9  disp(v,"Therefore ,   V_r2(in V)=(I*R2)=(V*R2)/(R1+R2+
       R3)=")
10 v=1*30
11 disp(v,"and ,   V_r3(in V)=(I*R3)=(V*R3)/(R1+R2+R3)=")
12 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`

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

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

Scilab code Exa 1.5 `find the values of currents`

```
1  //example1.5
2  clc
3  disp("Application of Kirchhoffs law:")
4  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.")
5  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).")
6  disp("Step 4: Apply KVL to different loops.")
7  disp("Loop 1: A–B–E–F–A , −15(I_1)−20(I_2)+50=0")
8  disp("Loop 2: B–C–D–E–B , −30((I_1)−(I_2))−100+20(
       I_2)=0")
9  disp("Rewriting all the equations,taking constants
       in one side.")
10 disp("15(I_1)+20(I_2)=50   ..(1)")
11 disp("−30(I_1)+50(I_2)=100   ..(2)")
12 disp("Apply cramers rule,")
13 d=(15*50)-(-30*20)
14 format(5)
```

```
15  disp (d,"D=[15  20;−30  50]=")
16  disp ("Calculating  D_v")
17  d=(50*50)-2000
18  disp (d,"D1=[50  20;100  50]=")
19  i=500/1350
20  disp (i,"I_1 (in  amp)=(D_1)/D=")
21  disp ("Calculating  D2 ,")
22  d=1500+(30*50)
23  disp (d,"D2=[15  50;−30  100]=")
24  i=3000/1350
25  disp (i,"I_2 (in  amp)=D2/D=")
26  disp ("For  I_1  and  I_2 ,  as  answer  is  positive ,
         assumed  direction  is  correct")
27  disp ("Therefore ,  for  I_1  answer  is  0.37  amp.  For  I_2
          answer  is  2.22 amp")
28  i=0.37-2.22
29  format (5)
30  disp (i,"(I_1)−(I_2)[in  amp]=")
31  disp ("Negative  sign  indicates  assumed  direction  is
         wrong .")
32  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`

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

```
8  disp(" −1∗(5+3(i2))+5(i2)=0      ...(2)")
9  disp(" 2(i2)=5")
10 i=5/2
11 disp(i," i2 (in amp)=")
12 disp(" from eq.(1)")
13 i=5+(3∗2.5)
14 disp(i," i1 (in amp)=")
```

Scilab code Exa 1.7 `transform voltage source to current source`

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

Scilab code Exa 1.8 `convert current source to voltage source`

```
1  //example
2  clc
3  disp(" The given values are, I=50A and R_sh= 10ohm")
4  disp(" For the equivalent voltage source ,")
5  v=10∗50
6  disp(v," V(in V)=(I∗R_sh)=")
7  disp(" R_se=R_sh=10ohm in series.")
8  disp(" The equivalent voltage source is shown in the
       fig 1.46(a)")
```

```
9 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`

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

Scilab code Exa 1.10 `find equivalent resistance`

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

Scilab code Exa 1.11 `find equivalent resistance`

```
1 //example1.11
```

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

Scilab code Exa 1.12 `find current`

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

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

Scilab code Exa 1.13 `find power`

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

18

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

Scilab code Exa 1.14 `find current`

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

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

Scilab code Exa 1.15 `node voltage`

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

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

Scilab code Exa 1.16 `instantaneous current`

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

```
21 disp(" Therefore , ( I_m ) [ in A]=(V_m ) / (X_L)=")
22 disp(" In pure inductive circuit , current lags
      voltage by 90 degree . ")
23 disp(" Therefore , psi=phase difference = −90 degree
      =( pi /2) rad ")
24 disp(" Therefore , i=(I_m ) sin (wt−psi ) i.e. i ( in A)
      =3.37 sin ((100∗ pi ∗t )−(pi /2 ) ) ")
25 disp(" The phasor dig in shown in the fig 1.85(b) . ")
26 disp(" Case 3: C=50 micro−F")
27 c=1/(2∗%pi∗50∗50∗10^−6)
28 format (6)
29 disp(c ," Capacitive reactance , X_c ( in ohm)=1/wC
      =1/(2∗ pi ∗f ∗C)=")
30 i=212.13/63.66
31 format (5)
32 disp(i ," I_m ( in A)=(V_m ) / (X_c )=")
33 disp(" In pure capacitive circuit , current leads
      voltage by 90 degree . ")
34 disp(" Therefore psi=phase difference =90 degree= (
      pi /2) radian ")
35 disp(" Therefore , i=(I_m ) sin (wt+psi ) ")
36 disp(" Therefore , i ( in A)=3.33 sin ((100∗ pi ∗t )+(pi /2 ) )
      ")
37 disp(" The phasor dig is as shown in the fig 1.85(c) .
      ")
38 disp(" All the phasor dig represent r.m.s values of
      voltage and current ")
```

Scilab code Exa 1.17 `find voltage`

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

```
6  disp(r,"R2(in ohm)=(3*2)/(2+5+3)=")
7  r=15/10
8  disp(r,"R3(in ohm)=(5*3)/(2+5+3)=")
9  r=50/25
10 disp(r,"R1(in ohm)=(10*5)/(10+5+10)=")
11 r=100/25
12 disp(r,"R2(in ohm)=(10*10)/(10+5+10)=")
13 r=50/25
14 disp(r,"R3(in ohm)=(5*10)/(10+5+10)=")
15 disp("The circuit reduces as shown in the fig 1.86(c
      )")
16 r=0.6+4.2439+2
17 format(7)
18 disp(r,"R_ab(in ohm)=0.6+4.2439+2=")
19 disp("as, I=V/R_ab")
20 v=5*6.8439
21 format(8)
22 disp(v,"Therefore,  V(in V)=I*R_ab=")
```

Scilab code Exa 1.18 `equivalent resistance`

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

Scilab code Exa 1.19 `find current`

```
1  //example1.19
2  clc
3  disp("Using the loop analysis, (fig 1.88(a) see on
       next page)")
4  disp("Applying KVL to the three loops,")
5  disp("-(I1)-(I1)-2(I1)+2(I3)+5-2(I1)=0   i.e   -6(I1)
       +2(I3)= -5    ...(1)")
6  disp("-2(I3)+2(I1)-2(I3)-5-2(I3)-(I3)+I2=0   i.e    2(
       I1)+I2-7(I3)=5     ...(2)")
7  disp("-2(I2)-(I2)+(I3)-2(I2)+5=0     i.e   -5(I2)+I3=
       -5   ...(3)")
8  disp("Solving equation (1),(2)and (3)")
9  disp("so, putting equations(1) and (3) in eq (2),we
       get")
10 disp("10(I3)+25+3(I3)+15-105(I3)=75")
11 disp("Therefore, -92(I3)=35")
12 i=(-35)/92
13 format(7)
14 disp(i,"Therefore, I3(in A)=")
15 disp("Now, putting value of I3 in equations (1) and
       (2) :")
16 i=((-35/46)+5)/6
17 disp(i,"Therefore, I1(in A)=")
18 i=((-35/92)+5)/5
19 disp(i,"and, I2(in A)=")
20 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`

```
1  //example1.20
2  clc
3  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 ,")
 4  disp(" −4( i2 )−(R∗ i2 )−2( i1 )+10=0")
 5  disp(" i . e     2( i1 )+4( i2 )+(R∗ i2 )=10      . . Loop  AOBA")
 6  disp(" −( i1−i2 )−1.5( i1−i2 )−2( i1 )+10=0")
 7  disp(" i . e    +4.5( i1 )−2.5( i2 )=10      . . Loop  ACBA")
 8  disp(" −( i1−i2 )−1.5( i1−i2 )+(R∗ i2 )+4( i2 )=0")
 9  disp(" i . e     −2.5( i1 )+6.5( i2 )+(R∗ i2 )=0      . . Loop
      ACBOA")
10  disp("As  current  through  branch  OC  is  zero ,  points  O
        and  C  are  equipotential . So  drop  across  AO  is
      same  as  drop  across  AC.")
11  disp("Therefore ,     4( i2 )=( i1−i2 )     i . e      ( i1 )=5( i2
      )")
12  disp("Using  in  loop  A–C–B–A,  4.5∗5∗( i2 )−2.5( i2 )=10")
13  i =10/20
14  disp( i ,"Therefore ,     i2 ( in  A)=")
15  i =5∗0.5
16  disp( i ,"and ,  i1 ( in  A)=")
17  disp("Using  in  loop  A–O–B–A,  (2∗2.5)+(4∗0.5)+0.5(R)
      =10")
18  r =3/0.5
19  disp( r ,"Therefore ,    R( in  ohm)=")
20  disp("And  current  through  R  is  i2 =0.5  A")
```

Scilab code Exa 1.21 `find current`

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

```
 9 disp("Using in the equations (1) and (2),")
10 disp("21−(V1/2)−(V1−V2)/3 = 0")
11 disp("i.e   0.8333(V1) −0.333(V2) = 21     ...(3)")
12 disp("[(V1−V2)/3]−(V2/3)−(V2/6)=0")
13 disp("i.e   0.3333(V1) −0.8333(V2) = 21     ...(4)")
14 disp("Solving equations (3) and (4),")
15 disp("0.8333(V1) −0.333(0.3333/0.8333)V1=21")
16 v=(-21*0.8333)/((0.333*0.3333)-(0.8333)^2)
17 format(3)
18 disp(v,"V1(in V)=")
19 v=(0.3333*30)/0.8333
20 disp(v,"V2(in V)=")
21 i=-12/6
22 disp(i,"Therefore, I(in 6ohm)=I4(in A)=")
23 disp("The current flows in downward direction in 6
      ohm resistor.")
24 disp("Voltage across current soource is the voltage
      across 2ohm resistance, which is node voltage V1
      =30 V.")
25 p=30*21
26 format(4)
27 disp(p,"Therefore, power supplied by source P(in W)=
      V1*21=30*21=")
```

Scilab code Exa 1.22 `find voltage`

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

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

Scilab code Exa 1.23 `find current`

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

```
)
```

Scilab code Exa 1.24 `find voltage drop`

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

Scilab code Exa 1.25 `find inductive resistance`

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

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

Scilab code Exa 1.26 `find resistance`

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

Scilab code Exa 1.27 `find resistance`

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

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

Scilab code Exa 1.28 `find resistance`

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

Scilab code Exa 1.29 `find resistance`

```
1  //example1.29
```

```
 2 clc
 3 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 ")
 4 r=25/15
 5 disp (r ,"R( in ohm)=(5*5)/(5+5+5)=")
 6 disp (" Convert the delta of 6.667ohm, 5ohm and 11.667
      ohm")
 7 r =(6.667*11.667)/(6.667+11.667+5)
 8 format (7)
 9 disp (r ,"R1( in ohm)=(6.667*11.667)/(6.667+11.667+5)="
      )
10 r =(6.667*5)/(6.667+11.667+5)
11 disp (r ,"R2( in ohm)=(6.667*5)/(6.667+11.667+5)=")
12 r =(5*11.667)/(6.667+11.667+5)
13 format (7)
14 disp (r ,"R3( in ohm)=(5*11.667)/(6.667+11.667+5)=")
15 r=5.333+2.612
16 format (7)
17 disp (r ," Therefore , R_ab( in ohm)=5.333+2.612=")
```

Scilab code Exa 1.30 `find current`

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

```
11  disp (m , " For  2<=t <=4,  v ( t )=mt+c        where      m=(0−10)
        /(4−2)=")
12  disp ( " Therefore ,       v ( t )= −5t+C" )
13  c =5*4
14  disp ( c , "Now  at  t=4,   v ( t )=0   i . e .   0= −5*4+C    i . e
            C=")
15  disp ( " Therefore ,      v ( t )= −5t +20" )
16  disp ( " Therefore ,       i ( t )=v ( t )/R= (−5t +20)/40=  −0.125
        t +0.5" )
17  disp ( "At  t=4,  v ( t )= −5*4+20=0  V ,   i ( t )=
        −0.125*4+0.5=  0  V" )
18  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`

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

```
15  disp(i,"I(2ohm)[in A]=I1-2=")
16  disp("I(1ohm)[in A]=I2=3.8181")
17  i=3.0909-2-3.8181
18  disp(i,"I(3ohm)[in A]=I1-2-I2=")
19  disp("Current through 3ohm is negative i.e. it is
       flowing in opposite direction to that assumed in
       the circuit.")
20  disp("Method II: Loop analysis")
21  disp("From the current source branch,")
22  disp("I3= 2 A")
23  disp("Applying KVL to the other two loopos without
       current source,")
24  disp(" -2(I1)+2(I3)-I1+I2+6=0       i.e.       -3(I1)+I2=
       -10   ..(1)")
25  disp(" -3(I2)+3(I3)-12-I2+I1=0     i.e.       I1-4(I2)=6
       ..(2)")
26  disp("Solving we get,")
27  disp("I1-4(-10+3(I1))=6")
28  i=34/11
29  disp(i,"I1(in A)=")
30  i=(3.0909-6)/4
31  disp(i,"and,   I2(in A)=")
32  disp("Currents through various resistances are,")
33  i=3.0909-2
34  disp(i,"I(2ohm)[in A]=I1-2=")
35  i=3.0909+0.7272
36  disp(i,"I(1ohm)[in A]=I1-I2=")
37  i=-0.7272-2
38  disp(i,"I(3ohm)[in A]=I2-2=")
39  disp("The currents are same as obtained by the
       method 1.")
```

Scilab code Exa 1.32 `calculate current`

```
1  //example1.32
```

```scilab
2  clc
3  disp("Use the loop analysis")
4  disp("From the current source branch,")
5  disp("I3=1 A")
6  disp("Applying KVL to the loops without current
       source we get,")
7  disp("-6(I1)-4-5(I1)+5(I2)=0      i.e.      -11(I1)+5(I2
       )=4   ..(1)")
8  disp("-5(I2)+5(I1)-6-4(I2)-4(I3)=0   i.e.      5(I1)-9(
       I2)=10   (2)")
9  disp("Solving, we get:")
10 disp("-11(I1)+5((5I1-10)/9)=4")
11 disp("Therefore,      -99(I1)+25(I1)-50=36")
12 i=86/(-74)
13 format(7)
14 disp(i,"Therefore,        I1(in A)=")
15 i=((5*(-1.1621))-10)/9
16 disp(i,"and,     I2(in A)=")
17 disp("Current through 5ohm in specified direction is
       ,")
18 i=(-1.7567+1.1621)
19 disp(i,"I(5ohm)[in A]=I2-I1= -1.7567-(-1.1621)=")
20 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`

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

Scilab code Exa 2.2 `generated emf and speed`

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

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

Scilab code Exa 2.3 induced emf of generator

```
1  //example2.3
2  clc
3  disp("Consider shunt generator as shown in the fig
        2.29")
4  disp("I_a=(I_L)+(I_sh)")
5  disp("I_sh=(V_t)/(R_sh)")
6  disp("Now, V_t=250 V")
7  disp("and, R_sh=100 ohm")
8  i=250/100
9  disp(i,"Therefore, I_sh(in A)=")
10 disp("Load power=5 kW")
11 disp("Therefore, P=(V_t)*(I_L)")
12 i=(5*10^3)/250
13 disp(i,"I_L(in A)=P/(V_t)=")
14 i=20+2.5
15 disp(i,"(I_a)[in A]=(I_L)+(I_sh)=")
16 disp("E=(V_t)+((I_a)*(R_a))[neglect V_brush]")
17 E=250+(22.5*0.22)
18 disp(E,"Therefore, E(in V)=")
```

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

Scilab code Exa 2.4 `armature resistance of generator`

```
1  //example2.4
2  clc
3  disp(" Consider  separately  excited  generator  as  shown
        in  the  fig  2.30")
4  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")
5  disp(" Therefore ,      V_t=250V       and       P=10kW")
6  disp("and ,   P=(V_t)*(I_L)")
7  i=(10^4)/250
8  disp(i," Therefore ,      I_L (in  A)=")
9  disp(" Therefore ,      I_a=I_L=  40  A     ...As  separately
        excited")
10  disp("Now,   E=(V_t)+[(I_a)*(R_a)]+(V_brush)")
11  disp("Now  there  are  two  brushes  and  brush  drop  is  2V
        /brush")
12  v=2*2
13  disp(v," Therefore ,      V_brush(in  V)=")
14  disp(" Therefore ,      E=250+40(R_a)+4")
15  disp("But ,   E=255  V  on  full  load")
16  disp(" 255  =  250  +  40(R_a)  +  4")
17  r=1/40
18  disp(r," Therefore ,      R_a(in  ohm)=")
```

Scilab code Exa 2.5 `terminal voltage at load`

```
1  //example2.5
2  clc
```

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

Scilab code Exa 2.6 generated voltage

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

```
9  disp("E−[(I_a)*(R_a)]=(V_t)+[(I_t)*(R_se)]")
10 e=225+(75*0.02)
11 disp(e,"Therefore ,      E−[(I_a)*(R_a)]=")
12 disp("Therefore ,      I_sh=[E−(I_a)(R_a)]/(R_sh)=[(V_t
      )+(I_L)(R_se)]/(R_sh)")
13 i=226.5/90
14 format(7)
15 disp(i,"Therefore ,      I_sh(in A)=")
16 i=75+2.5167
17 disp(i,"Therefore ,      I_a=I_L+I_sh=")
18 disp("Therefore ,      E=V_t+[(I_a)*(I_sh)]+[(I_L)*(
      R_se)]")
19 e=225+(77.5167*0.04)+(75*0.02)
20 format(6)
21 disp(e,"E(in V)=")
```

Scilab code Exa 2.7 `induced emf in motor`

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

Scilab code Exa 2.8 `back emf and speed of motor`

```
1 //example2.8
2 clc
```

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

Scilab code Exa 2.9 gross torque

```
1  //example2.9
2  clc
3  disp("P=4, A=P=4, Z=480")
4  disp("psi=20mWb=20*10^-3 Wb, I_a=50 A")
5  t=(0.159*0.02*50*4*480)/4
6  format(7)
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 to

```
1  //example2.10
2  clc
3  disp("P=4,  A=P=4")
4  disp("Running light it is on no load.")
5  disp("Therefore,    N_0=1000 rpm    Z=540    and   psi
     =25*10^-3 Wb")
6  e=(100*540)/240
7  disp(e,"Therefore,  E_b0(in V)=(psi*P*N*Z)/(60*A)=")
```

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

Scilab code Exa 2.11 `speed of motor`

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

Scilab code Exa 2.12 `armature current and back emf`

```
1  //example2.12
2  clc
3  disp("V=250 V,   I_L=20 A,    R_s=0.3ohm,   R_sh=200
       ohm")
4  disp("I_L=(I_a)+(I_sh)")
5  s=250/200
6  disp(s,"(I_sh)[in A]=V/(R_sh)=")
7  disp("Therefore,     I_a=(I_L)-(I_sh)")
8  a=20-1.25
9  disp(a,"I_a(in A)=20-1.25=")
10 disp("Now,   V=(E_b)+(I_a*R_a)")
11 disp("Therefore,     E_b=V-[(I_a)*(R_a)]")
12 b=250-(18.75*0.3)
13 format(8)
14 disp(b,"E_b(in V)")
```

Scilab code Exa 2.13 `speed on full load`

```
1  //example2.13
2  clc
3  disp("Let no load,speed be N_0=1000 rpm")
4  disp("I_L0=Line current on no load=6 A")
5  disp("I_L0=(I_a0)+(I_sh)")
6  s=220/110
7  disp(s,"(I_sh)[in A]=V/(R_sh)=")
8  a=6-2
9  disp(a,"Therefore,   (I_a0)[in A]=(I_L0)-(I_sh)=")
10 disp("Therefore, Back emf on no load E_b0 can be
       determined from the voltage equation.")
11 disp("V=(E_b0)+[(I_a0)+(R_a)]")
12 disp("Therefore,     220=(E_b0)+(4*0.3)")
13 b=220-1.2
14 disp(b,"E_b0(in V)=")
```

```
15  disp("On full load condition ,supply voltage is
        constant and hence ,")
16  s=220/110
17  disp(s,"( I_sh )[ in A]=V/( R_sh )=")
18  disp("Now ,( I_L )=(I_aFL )+( I_sh )")
19  disp("Therefore ,     50=(I_aFL )+2")
20  f=50-2
21  disp(f ,"Therefore ,   (I_aFL )[ in A]=")
22  disp("And,   V=(E_bFL )+[( I_aFL )*( R_a )]")
23  disp("Therefore ,     220=(E_bFL +(48*0.3))")
24  b=220-(48*0.3)
25  disp(b ,"Therefore ,     (E_bFL )[ in V]=")
26  disp("From the speed equation ,")
27  disp("N directly proportional to (E_b )/psi")
28  disp("But psi is constant as I_sh is constant for
        both the load conditions")
29  disp("Therefore ,     (N_0 )/(N_FL )=(E_b0 )/(E_bFL )")
30  n=(1000*205.6)/218.8
31  format(7)
32  disp(n ,"Therefore ,     (N_FL )[ in rpm]=[( N_0 )*(E_bFL )
        ]/( E_b0 )=")
```

Scilab code Exa 2.14 `speed of motor on new load`

```
1  //example2.14
2  clc
3  disp("For load 1, N1=800 rpm ,    I1=(I_a1 )=20A")
4  disp("For load 2,   I2=(I_a2 )=50 A,   R_a=0.2 ohm ,
        R_se=0.3 ohm")
5  disp("From voltage equation V=(E_b1 )+[( I_a1 )*( R_a )
        ]+[( I_se1 )*( R_se )]")
6  disp("but    I1=(I_a1 )=(I_se1 )=20 A")
7  disp("Therefore ,     250=(E_b1 )+20(0.2+0.3)")
8  b=250-10
9  disp(b ,"Therefore ,     E_b1( in V)=")
```

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

Scilab code Exa 2.15 terminal voltage

```
1  //example2.15
2  clc
3  disp("Consider the generator as shown in fig 2.61")
4  disp("P=4,  A=P=4,  N=750 rpm,   psi=30 mWb=30*10^-3,
          Z=720")
5  n=(4*750*720*30*10^-3)/(240)
6  disp(n,"E(in V)=(psi*P*N*Z)/(60*A)=")
7  disp("E=(V_t)+[(I_a)*(R*a)]")
8  disp("(V_t)=(I_L)*(R_L)        i.e.     I_L=(V_t)/(R_L)"
       )
9  disp("And,  I_sh=(V_t)/(R_sh)")
10  disp("I_a=(I_L)+(I_sh)=[(V_t)/(R_L)]+[(V_t)/(R_sh)]"
       )
11  disp("Substituting in voltage equation,")
12  disp("E=(V_t)+[(V_t)/(R_L)+(V_t)/(R_sh)]*(R_a)")
13  disp("Therefore,     270=(V_t)+[(V_t)/(15)+(V_t)
        /(200)]*(0.4)")
14  disp("270=1.0286(V_t)")
```

```
15  v=270/1.0286
16  format(9)
17  disp(v,"V_t(in V)=")
```

Scilab code Exa 2.16 full load output and efficiency of motor

```
1  //example2.16
2  clc
3  disp("No load current I=2.5 A,")
4  n=440*2.5
5  disp(n,"No load input(in W)= (V*I)=")
6  s=440/550
7  disp(s,"I_sh(in A)=V/R_sh=")
8  disp("In dc shunt motor,    I=(I_sh)+(I_a)")
9  a=2.5-0.8
10 disp(a,"I_a(in A)=I-(I_sh)=")
11 p=1.2*(1.7)^2
12 format(6)
13 disp(p,"No load armature copper loss(in watts)= (R_a
      )*(I_a)^2=")
14 disp("Constant losses= No load input- No lpad
      armature Cu losses")
15 c=1100-3.468
16 format(9)
17 disp(c,"Therefore,    Constant losses(in Z)=")
18 disp("Now, full load line current i.e I=32 A")
19 disp("I=(I_sh)+(I_a)")
20 a=32-0.8
21 disp(a,"I_a(in A)=I-(I_sh)=")
22 p=1.2*(31.2)^2
23 disp(p,"Full load armature copper loss=(R_a)*(I_a)
      ^2=")
24 disp("Total losses= Full load armature Cu loss +
      Constant losses")
25 l=1168.128+1096.532
```

```
26  disp(l,"Therefore, Total losses(in W)=")
27  v=440*32
28  disp(v,"Full load motor input(in W)= V*I =")
29  v=14080-2264.66
30  disp(v,"Full load motor output(in W)= Input-Losses="
       )
31  d=(1181534)/14080
32  format(6)
33  disp(d,"% efficiency at full load= [(Full load
       Output)/(full load input)]*100=")
34  disp("Therefore,     Efficiency of motor at full load
       = 83.91%")
```

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

```
1  //example2.17
2  clc
3  disp("R_a=0.08 ohm, E_b1=242 V")
4  disp("i)    V=(E_b1)+[(I_a1)*(R_a)]")
5  disp("Therefore,    250=242+[(I_a1)*0.08]")
6  a=8/0.08
7  disp(a,"I_a1(in A)=")
8  disp("ii)   At start,   N=0 hence E_b=0")
9  a=250/0.08
10 disp(a,"(I_a(start))[in A]=V/(R_a)=")
11 disp("iii)   If  (I_a2)=120 A then,")
12 b=250-(120*0.08)
13 disp(b,"E_b2(in V)=V-[(I_a2)*(R_a)]=")
14 disp("iv)   Machine is running as a generator, shown
       in the fig 2.62")
15 disp("Let induced emf as generator be E_g")
16 g=250+(87*0.08)
17 format(7)
18 disp(g,"E_g(in V)=(V_t)+[(I_a)*(R_a)]=")
19 disp("In both cases as a motor or genrator E is
```

```
         directly prportional to (N*psi)")
20  disp("As flux is constant,  E is directly
       proportional to N")
21  disp("Therefore,    (E_b/E_g)=(N_m/N_g)")
22  disp("where      N_m= Speed as a motor    and      N_g=
       Speed as a generator")
23  disp("Therefore,    (242/256.96)=(1500/N_g)")
24  n=(1500*256.96)/242
25  disp(n,"N_g(in rpm)=")
```

Scilab code Exa 2.18 extra resistance to be added

```
1  //example2.18
2  clc
3  disp("V=200 V,  I_a1=30 A")
4  disp("Resistance across terminals=(R_a)+(R_se)=1.5
       ohm")
5  b=200-45
6  disp(b,"Therefore,     E_b1(in V)=V-[(I_a1)*(R_a-R_se
       )]=")
7  disp("N2=0.6(N1)")
8  disp("Therefore,    (N1/N2)=(1/0.6)")
9  disp("Use torque equation,")
10 disp("T is directly proportional to (psi*I_a) and (
       I_a)^2")
11 disp("as  ...  psi is directly proportional to I_a")
12 disp("Therefore,    (T1/T2)=[(I_a1)/(I_a2)]^2
       ..(1)")
13 disp("Also T is directly proportional to N^3 given,"
       )
14 disp("(T1/T2)=(N1/N2)^3=(1/0.6)^3    ..(2)")
15 disp("Equatimg equation (1) and (2),  (1/0.6)^3 =
       (30/I_a2)^2")
16 a=sqrt(900*(0.6^3))
17 format(8)
```

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```
18  disp(a,"Therefore ,      I_a2 (in A)=")
19  disp("E_b2=V−[(I_a2)*(R_a+R_se+R_x)
        ]=200−13.9427(1.5+R_x)    ..(3)")
20  disp("Use speed equation ,   N directly proportional
        to [(E_b)/psi] and [(E_b)/(I_a)]        ... psi
        id directly proportional to I_a")
21  disp("Therefore ,      (N1/N2)=[(E_b1)/(E_b2)]*[(I_a2)
        /(I_a1)]")
22  disp("Therefore ,      (1/0.6)=(155/E_b2)*(13.9427/30)"
        )
23  b=155*0.139427*2
24  format(6)
25  disp(b,"E_b2(in V)=")
26  disp("Equating equations (3) and (4) ,
        43.22=200−13.9427(1.5+R_x)")
27  r=[(200-43.22)/13.9427]-1.5
28  disp(r,"R_x(in ohm)=")
```

Scilab code Exa 2.19 `efficiency of motor`

```
1  //example2.19
2  clc
3  disp("No load current = I_L0 = 4 A")
4  s=250/250
5  disp(s,"I_sh[in A]=V/(R_sh)=")
6  a=4-1
7  disp(a,"Therefore ,   I_a0 (in A)=(I_L0)−(I_sh)=")
8  r=0.3*(3)^2
9  disp(r,"Therefore ,     No. load armature copper loss(
        in W)=[(I_a0)^2*(R_a)]=")
10 o=250*4
11 disp(o,"No load input(in W) = V*I_L0 =")
12 c=1000-2.7
13 disp(c,"Constant losses(in W) = No load input−No
        load armature copper loss=")
```

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```
14  disp("On full load,      I_L=60 A and I_sh=1 A")
15  j=60-1
16  disp(j,"Therefore,      I_a(in A)=(I_L)-(I_sh)=")
17  l=0.3*(59)^2
18  disp(l,"Full load armature copper loss(in W)= (I_a
        ^2)*R_a=")
19  l=997.3+2041.6
20  disp(l,"Total loss on full load=constant losses+ [(
        I_a)^2*(R_a) loss]=")
21  disp("Total input on full load = V*(I_L)")
22  l=250*60
23  disp(l,"Therefore,      P_in(in W)=")
24  p=15000-2041.6
25  format(8)
26  disp(p,"(P_out)[in W]=(P_in)-Total loss=")
27  n=1295840/15000
28  format(7)
29  disp(n,"% efficiency(n)=[(P_out)*100]/(P_in)=")
```

Scilab code Exa 2.20 lap and wave wound

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

Scilab code Exa 2.21 `emf generated`

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

Scilab code Exa 2.22 `speed of generator`

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

Scilab code Exa 2.23 `induced voltage`

```
1  //example2.23
2  clc
3  disp("The generator is shown in the fig 2.64")
4  disp("The current through R_se is I_L=80 A as the
       generator is short shunt.")
```

```
5  disp("The drop across R_sh is the sum of the drop
       across R_se and V_t")
6  disp(" [(I_sh)*(R_sh)]=(V_t)+[(I_L)*(R_se)]")
7  disp("i.e   100(I_sh)=250+(80*0.03)")
8  p=2.5+(0.8*0.03)
9  format(6)
10 disp(p,"(I_sh)[in A]=")
11 a=80+2.524
12 format(7)
13 disp(a,"(I_a)[in A]=(I_L)+(I_sh)=")
14 g=250+(82.524*0.05)+(80*0.03)+2
15 format(9)
16 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`

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

Scilab code Exa 2.25 `induced emf`

```
1  //example2.26
```

```
2 clc
3 disp("For a d.c. generator ,")
4 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")
5 disp("N1=1000 rpm, (psi_1)=0.02 Wb, (E_g1)-200 V, N2
      =1100 rpm, (psi_2)=0.019 Wb")
6 disp("[(E_g1)/(E_g2)]=[(N1*psi_1)/(N2*psi_2)]   i.e
      [(200)/(E_g2)]=[(1000*0.02)/(1100*0.019)]")
7 g=(200*1100*0.019)/(1000*0.02)
8 disp(g,"Therefore ,   E_g2(in V)=")
```

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

```
1 //example2.26
2 clc
3 disp("P=4, V=240 V, A=2 as wave, N=1000 rpm, P_out
      =11.19 kW")
4 disp("I_a=50 A, I_sh=50 A, R_a=0.1 ohm, Z=540")
5 disp("a) E_b=V-[(I_a)(R_a)]-Brush drop")
6 b=240-(50*0.1)-2
7 disp(b,"E_b(in V)=")
8 t=(233*50*60)/(2*%pi*1000)
9 format(9)
10 disp(t,"Therefore ,   T(in Nm)=[(E_b)(I_a)]/w=[(E_b)(
      I_a)]/[(2*pi*N)/60]=")
11 t=(11190*60)/(2*%pi*1000)
12 disp(t,"b)   T_sh(in Nm)=useful torque=(P_out)/w=")
13 disp("c) E_b=(psi*P*N*Z)/(60*A)     i.e     233=(psi
      *4*100*540)/(60*2)")
14 p=(233*60*2)/(4000*540)
15 format(6)
16 disp(p,"Therefore ,     psi(in Wb)=")
17 disp("Rotational losses= (T-T_sh)*w= (T-T_sh)*(2*pi*
      N)/60")
```

```
18  i=[(111.2493-106.8566)*(2*%pi*1000)]/60
19  format(4)
20  disp(i,"Therefore, Rotational losses(in W)=")
21  p=240*51
22  format(7)
23  disp(p,"P_in(in W)=V*(I_L)=V*(I_a+I_sh)=")
24  n=(11190*100)/12240
25  format(6)
26  disp(n,"% efficiency =[(P_out)*100]/(P_in)=")
```

Scilab code Exa 2.27 speed

```
1  //example2.27
2  clc
3  disp("V=250 V, N_0=1000 rpm, I_L0=5 A, R_a=0.2 ohm,
       R_sh=250 ohm")
4  i=250/250
5  disp(i,"I_sh(in A)=(V/R_sh)=")
6  i=5-1
7  disp(i,"Therefore, I_a0(in A)=(I_L0)-(I_sh)=")
8  e=250-(4*0.2)
9  disp(e,"E_b0(in V)=V-[(I_a0)(R_a)]=")
10 disp("on load, I_L1=50 A, (psi_1)=(psi_0)-(3% of (
       psi_0))=0.97(psi_0)")
11 disp("I_sh remains constant as long as V and R_sh
       are constant.")
12 i=50-1
13 disp(i,"I_a1(in A)=(I_L1)-(I_sh)=")
14 e=250-(49*0.2)
15 disp(e,"E_b1(in V)=V-[(I_a1)(R_a)]=")
16 disp("N is directly proportional to (E_b/psi)    ...
       Speed equation")
17 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)]")
```

```
18  n=(1000*240.2)/(249.2*0.97)
19  format(9)
20  disp(n,"Therefore,   N(in rpm)=")
```

Scilab code Exa 2.28 `torque`

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

Scilab code Exa 2.29 `induced emf and electrical power output`

```
1  //example2.29
2  clc
3  disp("P=4, N=1000 rpm, 80slots, psi=6*10^-2 Wb, 8
       conductors/slot")
4  disp("A=P=4      ... Lap connected")
5  z=80*8
6  disp(z,"Z= Slots*conductors/slot=")
7  e=(4*100*640*6*10^-2)/240
8  disp(e,"E_g(in V)=(psi*P*N*Z)/(60*A)=")
9  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")
```

```
10  a=4*50
11  disp(a,"Therefore ,   I_a(in A)=A*current per parallel
         path=4*50=")
12  p=640*200
13  disp(p,"P(in W)=Electrical power output=[(E_g)*(I_a)
         ]=")
```

Scilab code Exa 2.30 generated voltage and armature current

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

Scilab code Exa 2.31 induced emf and speed

```
1  //example2.31
2  clc
3  disp("P=8, N=400 rpm, psi=40 mWb, Z=960")
4  disp("a) Lap wound, A=P=8")
5  e=(8*400*960*40*10^-3)/(60*8)
6  disp(e,"E_g(in V)=(psi*P*N*Z)/(60*A)=")
7  disp("b) Wave connected , A=2, E_g =400 V")
```

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

Scilab code Exa 2.32 back emf and gross mechanical power

```
1  //example2.32
2  clc
3  disp("V=250 V, (R_a)=0.3 ohm, (I_L)=20 A, (R_sh)=200
       ohm")
4  s=250/200
5  disp(s,"I_sh(in A)=V/(R_sh)=")
6  a=20-1.25
7  disp(a,"I_a(in A)=(I_L)-(I_sh)=")
8  b=250-(18.75*0.3)
9  format(8)
10 disp(b,"E_b(in V)=V-[(I_a)(R_a)]=")
11 m=244.375*18.75
12 format(10)
13 disp(m,"P_m(in W)=[(E_b)*(I_a)]=")
```

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

```
1  //example2.33
2  clc
3  disp("The generator is shown in the fig 2.67")
4  s=500/200
5  disp("I_sh(in A)=(V_t)/(I_sh)=")
6  l=(25*10^3)/500
7  disp(l,"I_L(in A)=(P_L)/(V_t)=")
8  a=50+2.5
9  disp(a,"Therefore,  I_a(in A)=(I_L)+(I_sh)=")
```

```
10  disp("Brush drop is 1V per brush hence total brush
       drop = 2V")
11  e=500+[52.5*(0.03+0.04)]+2
12  format(8)
13  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=")
14  a=0.03*(52.5)^2
15  disp(a,"b)   Armature copper loss(in W) = [(I_a)^2]*(
       R_a) =[(52.5)^2]*(0.03) =")
16  s=0.04*(52.5)^2
17  disp(s,"Series field copper loss(in W) =[(I_a)^2]*(
       R_se) =[(52.5)^2]*(0.04) =")
18  c=200*(2.5)^2
19  disp(c,"Shunt field copper loss(in W) =[(I_sh)^2]*(
       R_sh) =[(2.5)^2]*(200) =")
20  p=505.675*52.5
21  format(11)
22  disp(p,"P_in(in W)= (E_g)*(I_a)=")
23  disp("P_out = 25W")
24  t=26547.9375-25
25  format(10)
26  disp(t,"Therefore,  Total losses(in W) = (P_in)-(
       P_out) =")
27  disp("Now total losses = Copper losses + Iron losses
       ")
28  disp("Therefore,  1547.9375 = 82.6875 + 110.25 +
       1250 + Iron losses")
29  i=1547.9375-(82.6875+110.25+1250)
30  format(4)
31  disp(i,"Therefore,  Iron losses(in W)=")
32  n=(25000*100)/(26547.9375)
33  format(8)
34  disp(n,"%efficiency(n) =[(P_out)/(P_in)]*100 =")
```

Scilab code Exa 2.34 total armature power

```
1  //example2.34
2  clc
3  disp(")i) As a generator")
4  disp("(P_out)=20 kW, (V_t)=250 V")
5  i=20000/250
6  disp(i,"I_L(in A)=(P_out)/(V_t)=")
7  s=250/125
8  disp(s,"I_sh(in A)=(V_t)/(R_sh)=")
9  a=80+2
10 disp(a,"Therefore,  I_a(in A)=(I_L)+(I_sh)=")
11 e=250+(82*0.1)
12 disp(e,"E_g(in V)= (V_t)+[(I_a)*(R_a)]=")
13 p=258.2*82
14 format(7)
15 disp(p,"P_g(in W)=(E_g)*(I_a)=")
16 disp("ii) As a motor")
17 disp("(P_in)=20 kW, V=250 V")
18 i=(20000)/250
19 disp(i,"Therefore, I_L(in A)=(P_in)/V=")
20 s=250/125
21 disp(s,"I_sh(in A)=V/(R_sh)=")
22 a=80-2
23 disp(a,"Therefore, I_a(in A)=(I_L)-(I_sh)=")
24 b=250-(78*0.1)
25 disp(b,"Therefore, E_b(in V)=V-[(I_a)*(R_a)]=")
26 a=242.2*78
27 format(8)
28 disp(a,"P_a(in W)=[(E_b)*(I_a)]=")
```

Scilab code Exa 2.35 `leakage coefficient`

```
1  //example2.25
2  clc
3  disp("P=4, N=750 rpm, (E_g)=240 V, A=2 as wave, Z
       =792")
```

```
4  disp(" (E_g)=(psi*P*N*Z)/(60*A)   i.e.   240=(psi
       *4*750*792)/(60*2)")
5  p=(240*60*2)/(4*750*792)
6  format(8)
7  disp(p,"Therefore, psi(in Wb)=")
8  disp("Lamda= Leakage coefficient = (Total flux)/(
       Useful flux)")
9  l=0.0145/0.01212
10 format(6)
11 disp(l,"Therefore, lamda = 0.0145/0.01212 =")
```

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

```
1  //exmaple2.26
2  clc
3  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")
4  i=(1500*1000)/550
5  format(10)
6  disp(i,"I_L(in A)=(P_out)/(V_t)=")
7  disp("As R_sh is not given, neglect I_sh hence (I_a)
       =2727.2727 A")
8  disp("a)   P_cu = Armature copper loss = [(I_a)^2]*(
       R_a)")
9  disp("25*10^3 = (2727.2727)^2 * (R_a)")
10 a=25000/[(2727.2727)^2]
11 format(9)
12 disp(a,"Therefore, (R_a)[in ohm]=")
13 e=550+(2727.2727*3.3611*0.001)
14 disp(e,"Therefore, E_g(in V)=(V_t)+[(I_a)*(R_a)]=")
15 disp("This is load terminal voltage.")
16 disp("b) (E_g)=(psi*P*N*Z)/(60*A)   i.e.   559.1667=(
       psi*10*150*2500)/(60*10)")
17 p=(559.1667*60*10)/(1500*2500)
18 format(8)
```

```
19  disp(p,"Therefore, psi(in Wb)=")
20  disp("Now, B=(psi)/A   i.e   0.9=(0.08946)/A")
21  a=0.08946/0.9
22  disp(a,"Therefore, A(in m^2)=")
```

Chapter 3

Transformers

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

```
1  //example3.1
2  clc
3  disp(" (B_m)=1 Wb/m^2 , E1=240 V, E/turn=8 V, f=50 Hz"
      )
4  disp("E1=E/turn * N1          i.e.      240=8*N1")
5  disp("Therefore , N1=30")
6  disp("Therefore , N1/N2=E1/E2   i.e   30/N2=240/2400")
7  disp("N2=300")
8  disp("E1=4.44*(psi_m)*f*N1          i.e.      240=4.44*(
      psi_m)*50*30")
9  p=240/(4.44*50*30)
10 format(8)
11 disp(p,"Therefore , (psi_m)[in Wb]=")
12 a=0.03636/1
13 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

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

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

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

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

Scilab code Exa 3.4 `primary current`

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

```
25  format(4)
26  disp(x,"y component of (I_0)=(I_0)*(psi_0)=")
27  disp("Therefore, vector(I_0)=0.9165+j(0.4) A")
28  i=25*sind(36.86)
29  format(7)
30  disp(i,"x component of I2''(in A)=I2''*sin(psi_2)=")
31  i=25*0.8
32  disp(i,"y component of I2''(in A)=I2''*cos(psi_2)=")
33  disp("Thus the two component of I1 are as shown in
        the fig 3.18(c)")
34  io=sqrt((15.9165^2)+(20.4^2))
35  disp(io,"I1(in A)=sqrt[((15.9165)^2)+(20.4)^2]=")
36  disp("This is the primary current magnitude.")
37  disp("while tan(phi_1)=15.9165/20.4")
38  t=atand(15.9165/20.4)
39  disp(t,"Therefore, (psi_1)[in degree]=")
40  disp("Hence the primary power factor is,")
41  i=cosd(37.96)
42  disp(i,"cos(psi_1)[lagging]=cos(37.96)=")
43  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

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

```
        primary ,  transfer  R2  to  primary  as  R2'',")
 7  r =0.01/((0.0606)^2)
 8  disp(r ,"R2''( in  ohm)=R2/K^2=")
 9  r =2.5+2.7225
10  format(7)
11  disp(r ,"Therefore ,  (R_1e)[ in  ohm]=R1+R2''=")
12  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 .")
13  disp("To  find  total  equivalent  resistance  referred
        to  secondary ,  first  calculate  R1'',")
14  r =2.5*(0.0606)^2
15  format(8)
16  disp(r ,"R1''( in  ohm)=(K^2)*R1=(0.0606^2)*2.5=")
17  r =0.01+0.00918
18  disp(r ,"(R_2e)( in  ohm)=R2*R1''=0.01*0.00918=")
```

Scilab code Exa 3.6 total resistance and equivalent reactance and impedance

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

```
13  r=9*(0.5^2)
14  disp(r,"Therefore, (R_2e)[in ohm]=(K^2)*(R_1e)=")
15  x=(0.5^2)*23
16  disp(x,"and, (X_2e)[in ohm]=(K^2)*(X_1e)=")
17  z=(0.5^2)*24.6981
18  format(7)
19  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`

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

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

Scilab code Exa 3.8 total copper loss and efficiency

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

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

Scilab code Exa 3.9 `maximum efficiency`

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

Scilab code Exa 3.10 `efficiency and unity power factor`

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

```
6  p=350/((15/20)^2)
7  format(8)
8  disp(p,"P_cu(FL)[in W]=")
9  disp("i) %n at cos(psi)=0.8 lag, full load")
10 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)]")
11 n=[20000*(0.8)*100]/[(20000*(0.8))+(622.222)+(350)]
12 format(7)
13 disp(n,"= ")
14 disp("ii) %n at cos(psi)=1 , full load")
15 n=(20000*100)/(20000+622.222+350)
16 format(8)
17 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

```
1  //Example 3.11
2  clc
3  disp("From O.C. test we can write,")
4  disp("  Wo = P1 = 50 W = Iron loss")
5  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.")
6  disp("V_sc = 15 V,  I_sc = 30 A,  W_sc = 100 W")
7  r2e=10/(30^2)
8  format(6)
9  disp(r2e,"Therefore,  R_2e (in ohm)= W_sc / (I_sc)^2
      =")
10 z1e=15/30
11 format(4)
12 disp(z1e,"  Z_1e(in ohm) = V_sc / I_sc =")
```

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```
13  x2e=sqrt((0.5^2)-(0.111^2))
14  format(7)
15  disp(x2e,"Therefore,  X_2e(in ohm) = sqrt(Z_2e^2 -
        R_2e^2) =")
16  disp("(i) Copper loss on full load")
17  i2=(10^4)/250
18  format(3)
19  disp(i2,"(I2)F.L (in A)= VA rating / V2 =")
20  disp("In short circuit test, I_sc = 30 A and not
        equal to full load value 40 A")
21  disp("Hence W_sc does not give copper loss on full
        load.")
22  disp("Therefore,  W_sc = P_cu at 30 A = 100 W")
23  disp("Now  P_cu  directly proprotional to  I^2")
24  disp("Therefore,  P_cu at 30 A / P_cu at 40 A =
        (30/40)^2")
25  disp("Therefore,  100 / P_cu at 40 A = 900/1600")
26  pcu=(1600*100)/900
27  format(7)
28  disp(pcu,"Therefore,  P_cu at 40 A (in W)= ")
29  disp("Therefore,  (P_cu)F.L = 177.78 W")
30  disp("(ii) Full load eta,  cos(phi2) = 0.8")
31  disp("%eta on full load = V2(I2)F.L.*cos(phi2)*100 /
        V2(I2)F.L.*cos(phi2)+Pi+(P_cu)F.L")
32  n=(250*40*0.8*100)/((250*40*0.8)+50+177.78)
33  format(6)
34  disp(n,"= (250*40*0.8*100)/((250*40*0.8)+50+177.78)
        = ")
35  disp("iii) Half load eta, cos(phi_2)=0.8")
36  disp("n=0.5 as half load,  (I2)[H.L.]=40/2 =20 A")
37  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")
38  disp("= n*(VA rating)*cos(phi2)*100 / n*(VA rating)*
        cos(phi2)+Pi+(P_cu)F.L")
39  disp("= 0.5*10*10^3*0.8*100/(0.5*10*10^3*0.8)
        +50+(0.5^2)*177.78")
40  n=(0.5*10*1000*0.8*100)/((0.5*0.8*10^4)
```

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

Scilab code Exa 3.12 `voltage and power factor`

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

```
18  disp("Therefore, (200^2)*0.055 = 54.8895*200*cos(
        phi_sc)")
19  s=((0.055*200)/(54.8895))
20  format(4)
21  disp(s,"Therefore, cos(phi_sc)[lagging]=")
```

Scilab code Exa 3.13 all day efficiency

```
1  //exmaple3.13
2  clc
3  disp("Given values are, P_i=2.5 kW, (P_cu)F.L. = 3.5
        kW, 400 kVA")
4  disp("Iron losses are constant for 24 hours. So
        energy spent due to iron lossses for 24 hours is,
        ")
5  p=2.5*24
6  disp(p,"P_i(in kWh)=2.5*24 hours=")
7  disp("Total energy output in a day from given load
        cycle is,")
8  e=(300*6)+(200*10)+(100*4)
9  disp(e,"Energy output (in kWh)= (300*6 hours)
        +(200*10 hours)+(100*4 hours)=")
10  disp("To calculate energy spent due to copper loass,
        ")
11  disp("i)Load 1 of 300 kW at cos(phi)=0.8")
12  k=300/0.8
13  disp(k,"Therefore, kVA supplied = kW/cos(phi)
        =300/0.8=")
14  n=375/400
15  format(7)
16  disp(n,"Therefore, n=(load kVA)/(kVA rating)
        =375/400=")
17  disp("Copper losses are proportional to square of
        kVA ratio i.e. n^2")
18  l=3.5*(0.9375)^2
```

```
19  format(6)
20  disp(l,"Therefore, Load 1 P_cu = n^2*(P_cu)F.L.
        =(0.9375)^2*3.5=")
21  e=3.076*6
22  format(7)
23  disp(e,"Energy spent(in kWh)=3.076*6 hours=")
24  disp("ii) Load 2 of 200 kW at cos(phi)=0.7")
25  k=200/0.7
26  format(9)
27  disp(k,"Therefore, kVA supplied=(kW)/cos(phi)
        =200/0.7=")
28  n=285.7142/400
29  format(7)
30  disp(n,"n=(Load kVA)/(kVA rating)=")
31  p=3.5*(0.7142^2)
32  disp(p,"Therefore, Load 2 P_cu(in kW)= n^2*(P_cu)F.L
        .= (0.7142^2)*3.5=")
33  p=1.7857*10
34  disp(p,"Therefore, Energy spent(in kWh)= 1.7857*10 =
        ")
35  disp("iii) Load 3 of 100 kW at cos(phi)=0.9")
36  k=100/0.9
37  format(8)
38  disp(k,"Therefore, kVA supplied=kW/cos(phi)=100/0.9=
        ")
39  n=111.111/400
40  format(7)
41  disp(n,"Therefore, n=111.111/400=")
42  p=3.5*(0.2778^2)
43  disp(p,"Therefore, Load 3 P_cu(in kW)= n^2*(P_cu)F.L
        .=(0.2778^2)*3.5= ")
44  e=0.2701*4
45  disp(e,"Therefore, Energy spent(in kWh)=0.2701*4=")
46  disp("iv) No load hence negligible copper losses.")
47  t=60+18.457+17.857+1.0804
48  format(8)
49  disp(t,"Therefore, Total energy spent = Energy spent
        due to [Iron losses + Total copper loss]=
```

```
      60+18.457+17.857+1.0804 = ")
50  disp("and  Total  output  =  4200  kWh")
51  disp("Therefore ,  All  day  eta=  ( Total  output  for  24
        hours )/( Total  output  for  24  hours+Total  energy
        spent  for  24  hours )")
52  n=420000/(4200+97.3944)
53  format (6)
54  disp(n,"=  4200*100/(4200+97.3944)  =  ")
```

Scilab code Exa 3.14 `copper loss and efficiency`

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

Scilab code Exa 3.15 `iron and copper loss`

```
1  //example3.15
2  clc
3  x=250*800
4  disp(x,"a)The output power at full load(in watt)=")
5  disp("THe input power at full load =(200*10^3)
      /0.98135")
6  disp("The total loss = Input-Output")
7  t=((200*10^3)/0.98135)-200000
8  format(8)
9  disp(t,"= ")
10 disp("Therefore , P_i + P_c = 3800.88         (i)")
11 disp("where      P_i= Iron loss   ,P_c = Full load
      copper loss")
12 p=125*800
13 disp(p,"The power output at half load=125*10^3 *0.8=
      ")
14 disp("The power input at half load = (100*10^3)
      /0.97751")
15 x=((100*10^3)/0.9775)
16 disp(x,"Total loss = (100*10^3)/0.9775 - 100*10^3 ="
      )
17 disp("(P_i)+ (0.5^2)*(P_c) = 2300.74")
18 disp("(P_i)+ (0.25)*(P_c) = 2300.74          (ii)")
19 disp("From equations (i) and (ii),")
20 disp("0.75*(P_i)=3800.88-2300.74")
21 p=(3800.88-2300.74)/0.75
22 disp(p,"Therefore , P_i(in watt)=")
23 z=3800.88-2000.18
24 disp(z,"P_c(in watt)=")
```

Scilab code Exa 3.16 `regulation`

```
1  //example3.16
```

```
 2  clc
 3  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")
 4  disp("For eta_max, P_cu=(P_i)=1200 W")
 5  i=(100*10^3)/10000
 6  disp(i,"(I_2)F.L.[in A] = VA rating/V2 = (100*10^3)
        /10000 = ")
 7  disp("Therefore, P_cu on any load/(P_cu)F.L. = [I2
        load/I2 F.L]^2    ...As (P_cu) directly
        proportional I^2")
 8  disp("Therefore, 500/(P_cu)F.L. = (6/10)^2")
 9  p=500*(10/6)^2
10  format(8)
11  disp(p,"Therefore, (P_cu)F.L.[in W] = ")
12  k=100*sqrt(1200/1388.88)
13  disp(k,"kVA at eta_max = (kVA rating)*sqrt(P_i/(P_cu
        )F.L) = 100*sqrt(1200/1388.88) =")
14  disp("Therefore, % eta_max = (kVA for n_max cos(phi)
        *100)/(kVA for n_max cos(phi)+2P_i)")
15  n=(92951.8*0.8*100)/((92951.8*0.8)+(2*1200))
16  disp(n,"= (92951.8*0.8*100)/((92951.8*0.8)+(2*1200))
        = ")
17  i=10*sqrt(1200/1388.88)
18  format(7)
19  disp(i,"(I_2m) at eta_max [in A]= (I_2)F.L. * sqrt(
        P_i/(P_cu)F.L.) = ")
20  disp("Therefore, (P_cu) at eta_max = P_i = (I_2m)^2
        * R_2e")
21  disp("Therefore, 1200 = (9.2951^2)*R_2e")
22  r=1200/(9.2951^2)
23  disp(r,"Therefore, R_2e[in ohm] = ")
24  disp("% R = (I_2m)[R_2e cos(phi)+(X_2e)sin(phi)
        *100]/V2")
25  po=(9.2951*((13.889*0.8)+(10*10*0.6)))/100
26  format(5)
27  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`

```
1  //exmaple3.17
2  clc
3  disp("5 kVA, 2300/230 V, P_i=40 W, (P_cu)F.L. =112 W
       , cos(phi)=0.8")
4  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")
5  disp("No.   output     =Actual kVA/total kVA        n
       ^2 P_cu(F.L.) ")
6  disp("1     1.25         0.25
                                      7
       95.51%")
7  disp("2       2.5          0.5
                                        28
                             96.711%")
8  disp("3     3.75          0.75
                                      63
       96.668%")
9  disp("4         5            1
                                         112
                             96.339%")
10 disp("5     6.25          1.25
                                       175
       95.877%")
11 disp("6       7.5          1.5
                                        252
                             95.359%")
12 disp("")
13 disp("The efficiency against kVA output curve is
       shown in the fig. 3.28")
```

Scilab code Exa 3.18 `load impedance and maximum flux`

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

Scilab code Exa 3.19 `number of primary and secondary turns`

```
1  //example3.19
2  clc
3  disp("E1=2300 V, E2=230 V, f=50 Hz, B_m=1.1 Wb/m^2 ,
       A=0.05 m^2")
4  disp("B_m=(phi_m)/A      i.e      1.1=(phi_m)/0.05")
5  p=1.1*0.05
6  format(6)
7  disp(p,"Therefore , (phi_m)[in Wb]=")
8  disp("E1=4.44(phi_m)*f*N1    i.e.
       2300=4.44*0.055*50*N1")
9  n=2300/(4.44*0.055*50)
10 format(7)
```

```
11 disp(n,"Therefore ,N1 = ")
12 disp("E2=4.44(phi_m)*f*N2    i.e.
      230=4.44*0.055*50*N2")
13 n=230/(4.44*0.055*50)
14 disp(n,"Therefore , N2 = ")
```

Scilab code Exa 3.20 maximum efficiency

```
1  //example3.20
2  clc
3  disp("150 kVA,  P_i=1.4 kW,  P_cu(FL)=1.6 kW")
4  k=150*sqrt(1.4/1.6)
5  format(9)
6  disp(k,"a) kVA for eta_max = kVA*sqrt(P_i/P_cu(FL))=
      ")
7  disp("For maximum efficieny , P_cu=P_i=1.4kW and cos(
      phi)=1")
8  disp("Therefore , %eta_max=(VA for eta_max *cos(phi))
      /(VA for eta_max*cos(phi)+2P_i *100")
9  n=(140.3121*1000*100)/(140312.1+(2*1.4*1000))
10 format(7)
11 disp(n,"= (140.3121*1000*100)/(140312.1+(2*1.4*1000)
      ) = ")
12 disp("b) At half load , n=0.5, cos(phi)=0.8")
13 disp("Therefore , %eta_HL = (n*VA*cos(phi)*100)/(n*VA
      *cos(phi)+P_i+[n^2 *P_cu(FL)])")
14 n=(0.5*150*1000*0.8*100)/((0.5*150*1000*0.8)
      +(1.4*10^3)+(1.6*1000*0.5^2))
15 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

```
1  //exmaple3.21
2  clc
3  disp("E1=1900 V, E2=240 V, f=50Hz, B_m=1.5 Wb/m^2,
       emf/turn = E1/N1 = E2/N2")
4  disp("Therefore, 1.5=1900/N1=240/N2")
5  n=1900/1.5
6  format(8)
7  disp(n,"Therefore, N1=")
8  n=240/1.5
9  disp(n,"and, N2=")
10 disp("E1=4.44*(phi_m)*f*N1  i.e.   1900=4.44(phi_m)
       *50*1267")
11 p=1900/(4.44*50*1267)
12 format(9)
13 disp(p,"Therefore, (phi_m)[in Wb]=")
14 disp("(B_m)=(phi_m)/A   i.e.   1.5=(6.7567*10^−3)/A")
15 a=(6.7567*10^-3)/1.5
16 format(10)
17 disp(a,"Therefore, A(in m^2)=")
18 i=10000/240
19 format(7)
20 disp(i,"I2(in A)=Output VA/E2 = (10*10^3)/240 = ")
```

Scilab code Exa 3.22 `efficiency`

```
1  //example3.22
2  clc
3  disp("%eta_FL = 96%, cos(phi)=0.8, %eta_HL =97.2%,
       cos(phi)=1")
4  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))")
5  disp("Therefore, P_i+P_cu(FL)=8333.333       ...(1)")
6  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")
```

```
7  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")
8  disp("Therefore, P_i+(0.5^2)*P_cu(FL)=3600.823
       ..(2)")
9  disp("Solving equations (1) and (2),")
10 disp("3600.823-(0.5^2)*P_cu(FL)+P_cu(FL)=8333.333")
11 disp("0.75*(P_cu)FL=8333.333-3600.823")
12 p=(8333.333-3600.823)/0.75
13 format(9)
14 disp(p,"P_cu(FL)[in W]=")
15 p=8333.333-6310.013
16 format(9)
17 disp(p,"P_i(in W)=")
18 disp("At 75% of full load, n=0.75 and cos(phi)=0.8")
19 disp("Therefore, %eta=(n*VA*cos(phi))/(n*VA*cos(phi)
       +P_i+(n^2)*P_cu(FL)) *100")
20 disp("=(0.75*2508(10^3)*0.8)/(0.75*250*(10^3)
       *0.8+2023.319+(0.75^2)*6310.013)) *100")
21 n=(0.75*250*(10^3)*0.8*100)/((0.75*250*(10^3)*0.8)
       +2023.319+((0.75^2)*6310.013))
22 format(8)
23 disp(n,"= ")
```

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

```
1  //example3.23
2  clc
3  disp("V_0=220 V, I_0=0.5 A, W_0=30 W, R1=0.6ohm")
4  disp("W_0=(V_0)*(I_0)*cos(phi_0)    i.e.    cos(
       phi_0)=30/(220*0.5)")
5  c=30/(220*0.5)
6  format(8)
7  disp(c,"Therefore, cos(phi_0)=")
8  p=acosh(0.27272)
9  disp(p,"i.e. (phi_0)[in degree]=")
```

```
10 k=110/220
11 disp(k,"a) K=Turns ratio=Secondary voltage/Primary
      voltage=110/220=")
12 i=0.5*0.27272
13 disp(i,"b) I_m(in A)=(I_0)*cos(phi_0)=0.5*0.27272=")
14 i=0.5*sind(74.1733)
15 format(6)
16 disp(i,"I_c(in A)=(I_0)*sin(phi_0)=0.5*sin(74.1733)=
      ")
17 p=30-((0.5^2)*0.6)
18 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

```
1 //example3.24
2 clc
3 disp("50 kVA, P_i=500 W, P_cu(FL)=600 W")
4 disp("a)    cos(phi)=1, Full load")
5 n=(50*(10^3)*1*100)/((50*10^3)+500+600)
6 format(7)
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)= ")
8 k=50*sqrt(500/600)
9 format(8)
10 disp(k,"b) kVA at eta_max= kVA*sqrt(P_i/P_cu(FL))
      =50*sqrt(500/600)= ")
11 i=(50*10^3)/400
12 disp(i,"I_2(FL)[in A]=VA/V2=(50*10^3)/400=")
13 i=125*sqrt(500/600)
14 format(9)
15 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

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

Scilab code Exa 3.26 voltage regulation and efficiency

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

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

Scilab code Exa 3.27 `all day efficiency`

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

```
        energy spent due to iron losses,")
 6 p=1.6*24
 7 disp(p,"P_i(in kWh)=1.6*24= ")
 8 e=(6*160)+(4*80)+(1*0)
 9 disp(e,"Energy Output(in kWh)= (6*160)+(4*80)+(1*0)
        = ")
10 disp("To calulate energy spent due to copper loss:")
11 disp("Load 1: 160 kW, cos(phi)=0.8")
12 k=160/0.8
13 disp(k,"Therefore, kVA=kW/cos(phi)=160/0.8=")
14 e=3.02*6
15 disp(e,"Therefore, E1(in kWh)=P_cu(FL)*hours=3.02*6=
        ")
16 disp("Load 2: 80kW, cos(phi)=1")
17 k=80/1
18 disp(k,"Therefore, kVA=kW/cos(phi)=80/1=")
19 n=80/200
20 disp(n,"Therefore, n=Fraction of load=(load kVA)/(
        kVA rating)=80/200=")
21 p=(0.4^2)*3.02
22 format(7)
23 disp(p,"Therefore, P_cu(in kW)=(n^2)*P_cu(FL)
        =(0.4^2)*3.02=")
24 e=0.4832*4
25 disp(e,"Therefore, E2(in kWh)=P_cu*hours=0.4832*4=")
26 t=38.4+18.12+1.9328
27 format(8)
28 disp(t,"Total energy spent(in kWh)=P_i+E1+E2
        =38.4+18.12+1.9328= ")
29 n=(1280*100)/(1280+58.4528)
30 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`

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

Scilab code Exa 4.2 `calculate coil factor`

```
1  //Example  4.2
2  clc
```

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

Scilab code Exa 4.3 `find induced emf`

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

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

Scilab code Exa 4.4 `find poles and flux`

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

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

Scilab code Exa 4.5 `calculate emf`

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

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

Scilab code Exa 4.6 `calculate lagging`

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

```
18  disp(p,"Therefore ,   E_ph(in V) = ")
19  regu=((4166.06-3810.512)/3810.512)*100
20  format(5)
21  disp(regu,"Therefore , %Regulation(in percentage) = (
        E_ph-V_ph / V_ph)*100 =")
22  disp("(ii) For 0.8 leading p.f. load")
23  disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
        sin(phi)+I_a*X_s)^2")
24  eph=(((3810.512*0.8)+(104.97*0.25))^2)
        +(((3810.512*0.6)-(104.97*5))^2)
25  p=sqrt(eph)
26  format(8)
27  disp(p,"Therefore ,   E_ph(in V) = ")
28  regu=((3543.47-3810.512)/3810.512)*100
29  format(5)
30  disp(regu,"Therefore , %Regulation(in percentage) = (
        E_ph-V_ph / V_ph)*100 =")
31  disp("The regulation is negative for leading p.f.
        loads")
```

Scilab code Exa 4.7 `calculate full load`

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

```
12  disp("For calculation of Z_s on full load, it is
        necessary to plot O.C.C. and S.C.C. to the scale"
        )
13  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.")
14  disp("In this problem, I_ssc = 25 A for I_f = 1 A")
15  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.")
16  disp("For plotting O.C.C. the lines values of open
        circuit voltage are converted to phase by
        dividing each value by sqrt(3)")
17  disp("From S.C.C.")
18  disp("For     I_scc = 66.67 A,   I_f = 2.4 A")
19  disp("From O.C.C.")
20  disp("For     I_f = 2.4 A,   (V_oc)_ph = 240 V")
21  disp("From the graph, Z_s for full load is,")
22  disp("Z_s = (V_oc)_ph / (I_scc)_ph |for same
        excitation")
23  zs=240/66.67
24  format(4)
25  disp(zs,"Therefore,   Z_s(in ohm/phase) =")
26  disp("R_a = 0.15 ohm/phase")
27  xs=sqrt((3.6^2)-(0.15^2))
28  format(6)
29  disp(xs,"Therefore,   X_s(in ohm/phase) = sqrt(Z_s^2
        - R_a^2) =")
30  disp("V_ph F.L = 500 V")
31  disp("cos(phi) = 0.8")
32  disp("Therefore,   sin(phi) = 0.6 lagging p.f.")
33  disp("So E_ph for full load, 0.8 lagging p.f.
        condition can be calculated as,")
34  disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
        sin(phi)+I_a*X_s)^2")
```

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

Scilab code Exa 4.8 `find current`

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

```
        − R_a ^2) =")
19  disp("Now regulated is asked for I_a = 10 A")
20  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")
21  disp("(i) For 0.8 lagging p.f.")
22  vph=230/sqrt(3)
23  format(7)
24  disp(vph,"V_ph(in V) = V_L/sqrt(3) =")
25  disp("I_a = 10 A")
26  disp("cos(phi) = 0.8     so sin(phi) = 0.6")
27  disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
        sin(phi)+I_a*X_s)^2")
28  eph=(((132.79*0.8)+(10*0.9))^2)+(((132.79*0.6)
        +(10*10.585))^2)
29  p=sqrt(eph)
30  format(8)
31  disp(p,"Therefore,  E_ph(in V) = ")
32  regu=((218.39-132.79)/132.79)*100
33  format(6)
34  disp(regu,"Therefore, %Regulation(in percentage) = (
        E_ph−V_ph / V_ph)*100 =")
35  disp("(ii) For 0.8 leading p.f.")
36  disp("(E_ph)^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
        sin(phi)+I_a*X_s)^2")
37  eph=(((132.79*0.8)+(10*0.9))^2)+(((132.79*0.6)
        -(10*10.585))^2)
38  p=sqrt(eph)
39  format(8)
40  disp(p,"Therefore,  E_ph(in V) = ")
41  regu=((118.168-132.79)/132.79)*100
42  format(6)
43  disp(regu,"Therefore, %Regulation(in percentage) = (
        E_ph−V_ph / V_ph)*100 =")
```

Scilab code Exa 4.9 find armature conductors

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

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

Scilab code Exa 4.10 `calculate flux`

```
1  // Exmaple  4.10
2  clc
3  disp ( " N_s  =  250  r . p .m . ,    f  =  50  Hz " )
4  disp ( " slots  =  288 ,   E_line  =  6600  V " )
5  disp ( " N_s  =  120∗ f /P " )
6  p = (120∗50) /250
7  format (3)
8  disp (p , " Therefore ,   P  = " )
9  n =288/24
10  disp (n , " n  =  slots / pole  = " )
11  m =12/3
12  disp (m , " m  =  n /2  = " )
13  beta =180/12
14  disp ( beta , " beta  =  180/n  = " )
15  kd = sind (30) /(4∗ sind (7.5) )
16  format (7)
17  disp ( kd , " Therefore ,   K_d  =  sin (m∗ beta /2)  /  m∗ sin (
        beta /2)  = " )
18  disp ( " Now  coil  is  short  pitched  by  2  slots " )
19  al =2∗15
20  disp ( al , " Therefore ,   alpha  =  angle  of  short  pitch  =
        2  ∗  beta  = " )
21  kc = cosd (15)
22  disp ( kc , " Therefore ,   K_c  =  cos ( alpha /2)  = " )
23  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 . " )
24  disp ( " Therefore ,   conductors / slot  =  32 " )
```

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```
25  disp ( ” Therefore ,  total conductors = slots x
        conductors / slot ” )
26  z=288*32
27  format (5)
28  disp (z , ” Therefore ,  Z =” )
29  zp=9216/3
30  disp (zp , ” Therefore ,  Z_ph = conductors / phase =” )
31  tp=3072/2
32  disp (tp , ” Therefore ,  T_ph = Z_ph/2 =
        ... 2 conductors −> 1 turn ” )
33  ep=6600/ sqrt (3)
34  format (8)
35  disp (ep , ”Now  E_ph ( in V) = E_line / sqrt (3) =” )
36  disp ( ” E_ph = 4.44∗ K_c∗K_d∗ phi ∗f∗T_ph ” )
37  phi =(3810.51/(4.44∗0.9659∗0.9576∗50∗1536))∗10^3
38  format (3)
39  disp ( phi , ” Therefore ,  phi ( in mWb) =” )
```

Scilab code Exa 4.11 `find rms vlaue`

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

```scilab
13  rms =1.11*4*60*0.05
14  format(6)
15  disp(rms ,"Therefore ,   r.m.s value(in V) = 1.11*4*f*
        phi =")
16  disp("(iii) Now each slot has 10 conductors and 2
        coil sides. So,")
17  c=10/2
18  disp(c,"conductors/coil side = 10/2 =")
19  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")
20  rmss =13.32*5
21  format(5)
22  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 =")
23  disp("(iv) Now total conductors  Z = conductors/
        slots * Number of slots")
24  z=10*180
25  disp(z,"Therefore ,  Z =")
26  zph =1800/3
27  disp(zph ,"Therefore ,  Z_ph = Z/3 =")
28  tph =600/2
29  disp(tph ,"T_ph = Z_ph/2 =")
30  n=180/12
31  disp(n,"And  n = slots/pole =")
32  m=15/3
33  disp(m,"m = n/3 =")
34  beta =180/15
35  disp(beta ,"beta(in degree) =")
36  kd=sind(30)/(5*sind(6))
37  format(7)
38  disp(kd,"Therefore ,  K_d = sin(m*beta/2) / m*sin(
        beta/2) =")
39  disp("E_ph = R.M.S value per turn*T_ph*K_d*K_c")
40  ep =13.32*300*0.9566*1
41  format(8)
42  disp(ep ,"Therefore ,  E_ph(in V) =")
```

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

Scilab code Exa 4.12 `find induced emf`

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

```
25  z=72*4
26  disp(z,"Therefore ,   Z = total conductors =")
27  zph=288/3
28  disp(zph,"Therefore ,   Z_ph = Z/3 =")
29  tph=96/2
30  disp(tph,"T_ph = Z_ph/2 =")
31  disp("Therefore ,   E_ph = 4.44*K_c*K_d*phi*f*T_ph")
32  eph=(4.44*0.9659*0.95766*1.5*50*48)*10^-3
33  format(8)
34  disp(eph,"Therefore ,   E_ph(in kV) =")
35  el=sqrt(3)*14.7852
36  disp(el,"Therefore ,   E_line(in kV) = sqrt(3)*E_ph ="
      )
```

Scilab code Exa 4.13 `find chording factor`

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

Scilab code Exa 4.14 `find emf`

```
1  //Example 4.14
2  clc
```

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

Scilab code Exa 4.15 `find reactance`

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

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

Scilab code Exa 4.15 `find reactance`

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

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

Scilab code Exa 4.16 `find impedence`

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

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

Scilab code Exa 4.17 find voltage regulation

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

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

Scilab code Exa 4.18 `find regulation`

```
1  //Example 4.18
2  clc
3  disp("2R_a = 2  i.e.  R_a = 1 ohm/ph")
4  disp("V_L = 3.6 kVA,  MVA = 1")
5  disp("Therefore,  VA = sqrt(3)*V_L*I_L")
6  il=(1*10^6)/(sqrt(3)*3.6*10^3)
7  format(8)
8  disp(il,"Therefore,  I_L(in A) = I_aph =          ...
        Star")
9  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")
10 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")
11 zs=(2250/sqrt(3))/160.37
12 format(4)
13 disp(zs,"Therefore,  Z_s(in ohm/ph) = V_ocph/I_scph
        |same I_f =")
14 xs=sqrt((8.1^2)-(1^2))
15 format(6)
16 disp(xs,"Therefore,  X_s(in ohm/ph) = sqrt(Z_a^2 -
```

```
        R_a^2) =")
17  vph =(3.6*10^3)/sqrt(3)
18  format(8)
19  disp(vph,"V_ph(in V) = V_L/sqrt(3) =")
20  disp("I_aph = 160.37 A")
21  disp("(i)   cos(phi) = 0.707 lagging,   sin(phi) =
        0.707")
22  disp("Therefore,   E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
        + (V_ph*sin(phi)+I_a*R_a)^2")
23  ephi=sqrt(((((2078.46*0.707)+(160.37*1))^2)
        +(((2078.46*0.707)+(160.37*8.038))^2)))
24  format(10)
25  disp(ephi,"Therefore,   E_ph(in V) =")
26  r=((3204.0356-2078.46)/2078.46)*100
27  format(6)
28  disp(r,"Therefore,   %R(in percentage) = (E_ph-V_ph /
        V_ph)*100 = ")
29  disp("(ii)   cos(phi) = 0.8 leading,   sin(phi) = 0.6"
        )
30  disp("Therefore,   E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
        + (V_ph*sin(phi)-I_a*R_a)^2")
31  ephi=sqrt(((((2078.46*0.8)+(160.37*1))^2)
        +(((2078.46*0.6)-(160.37*8.038))^2)))
32  format(10)
33  disp(ephi,"Substituting the values,   E_ph(in V) =")
34  r=((1823.6271-2078.46)/2078.46)*100
35  format(6)
36  disp(r,"Therefore,   %R(in percentage) = (E_ph-V_ph /
        V_ph)*100 = ")
```

Scilab code Exa 4.19 `find regulation`

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

```
 4  disp("VA = sqrt(3)*V_L*I_L")
 5  il=(10^6)/(sqrt(3)*11*10^3)
 6  format(7)
 7  disp(il,"Therefore,   I_L(in A) = I_aph(full load) ="
       )
 8  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")
 9  disp("From the graph, V_oc(line) = 6600 V for I_f =
       40 A")
10  zs=(6000/sqrt(3))/52.486
11  format(3)
12  disp(zs,"Therefore,   Z_s(in ohm) = V_ocph/I_ascph |
       same I_f =")
13  xs=sqrt((66^2)-(0.6^2))
14  format(7)
15  disp(xs,"Therefore,   X_s(in ohm) = sqrt(Z_s^2 - R_a
       ^2) =")
16  disp("(a) cos(phi) = 0.8 lagging,   sin(phi) = 0.6,
       half load")
17  ip=0.5*52.486
18  format(7)
19  disp(ip,"At half load,   I_aph(in A) = 1/2 * I_aph(FL
       ) =")
20  vp=(11*10^3)/sqrt(3)
21  format(9)
22  disp(vp,"V_ph(in V) = V_L/sqrt(3) =")
23  disp("E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*sin
       (phi)+I_a*R_a)^2")
24  ephi=sqrt(((((6350.853*0.8)+(26.243*0.6))^2)
       +(((6350.853*0.6)+(26.243*65.99))^2)))
25  format(10)
26  disp(ephi,"Therefore,   E_ph(in V) =")
27  r=((7529.3113-6350.853)/6350.853)*100
28  format(6)
29  disp(r,"Therefore,   %R(in percentage) = (E_ph-V_ph /
       V_ph)*100 = ")
30  disp("(b) cos(phi) = 0.9 leading,   sin(phi) =
```

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

Scilab code Exa 4.20 `find voltage`

```
1  //Example 4.20
2  clc
3  disp("R_s = 0.6 ohm,  X_s = 6 ohm,  I_aph = 180 A")
4  eph=6599/sqrt(3)
5  format(10)
6  disp(eph,"E_ph(in V) = E_line/sqrt(3) =")
7  disp("(a) cos(phi) = 0.9 lagging, sin(phi) = 0.4358"
       )
8  disp("Therefore,  E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
        + (V_ph*sin(phi)+I_a*R_a)^2")
9  disp("Therefore,  (3809.9344)^2 = [V_ph*0.9 +
       180*0.6]^2 + [V_ph*0.4358 + 180*6]^2")
10  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")
11  disp("Therefore,  V_ph^2 + 1135.728*V_ph - 13337536
       = 0")
12  disp("Therefore,  V_ph = 3128.08, -4263.808
        ... Neglect negative value")
13  disp("Therefore,  V_ph = 3128.08 V
        ... Terminal voltage")
```

```
14  r=((3809.9344-3128.08)/3128.08)*100
15  format(8)
16  disp(r,"Therefore,   %R(in  percentage) = (E_ph-V_ph /
        V_ph)*100 = ")
17  disp("(b) cos(phi) = 0.8 leading , sin(phi) = 0.6")
18  disp("Therefore,   E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2
        + (V_ph*sin(phi)+I_a*R_a)^2")
19  disp("Therefore,   (3809.9344)^2 = [V_ph*0.8 +
        180*0.6]^2 + [V_ph*0.6 + 180*6]^2")
20  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")
21  disp("Therefore,   V_ph^2 - 1123.2*V_ph - 13337536 =
        0")
22  disp("Therefore,   V_ph = 4256.5872 V          ...
        Neglect negative value")
23  r=((3809.9344-4256.5872)/4256.5872)*100
24  format(7)
25  disp(r,"Therefore,   %R(in  percentage) = (E_ph-V_ph /
        V_ph)*100 = ")
```

Scilab code Exa 4.21 `calculate regulation`

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

```scilab
        Star")
12  disp("    E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
        sin(phi)+I_a*R_a)^2")
13  ephi=sqrt(((((6928.2032*0.8)+(72.168*2))^2)
        +(((6928.2032*0.6)+(72.168*10))^2)))
14  format(9)
15  disp(ephi,"Therefore,   E_ph(in V) =")
16  r=((7492.768-6928.2032)/6928.2032)*100
17  format(6)
18  disp(r,"Therefore,   %R(in percentage) = (E_ph-V_ph /
         V_ph)*100 = ")
19  disp("(b) cos(phi) = 0.707 leading,   sin(phi) =
        0.707")
20  il=(1200*10^3)/(sqrt(3)*0.707*12*10^3)
21  format(6)
22  disp(il,"Therefore,   I_L(in A) = I_a =          ...
        Star")
23  disp("    E_ph^2 = (V_ph*cos(phi)+I_a*R_a)^2 + (V_ph*
        sin(phi)+I_a*R_a)^2")
24  ephi=sqrt(((((6928.2032*0.707)+(81.66*2))^2)
        +(((6928.2032*0.707)-(81.66*10))^2)))
25  format(10)
26  disp(ephi,"Therefore,   E_ph(in V) =")
27  r=((6502.2433-6928.2032)/6928.2032)*100
28  format(6)
29  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`

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

Scilab code Exa 5.2 `calculate full load speed`

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

110

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

Scilab code Exa 5.3 `frequency of induced emf`

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

Scilab code Exa 5.4 `find full load slip`

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

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

Scilab code Exa 5.5 `calculate frequency`

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

```
16  disp ("   N1/N2 = 2          Therefore ,   N2/N1 = 1/2 = K")
17  disp ("and   E_1line = 415 V")
18  disp ("The given values are always line values unless
        and until specifically stated as per phase .")
19  e1=415/sqrt (3)
20  format (6)
21  disp (e1 ," Therefore ,   E_1ph ( in V) = E_1/sqrt (3) =
                      ...As star connection E_line = sqrt
        (3)*E_ph")
22  disp (" Therefore ,   E_2ph/E_1ph = 1/2")
23  e2=239.6/2
24  disp (e2 ," Therefore ,   E_2ph ( in V) =               ...
        Rotor induced e.m.f on standstill ")
25  disp ("( iii ) In running condition ,")
26  er=0.03*119.8
27  disp (er ,"E_2r ( in V) = s*E_2 =")
28  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`

```
1  //Example 5.6
2  clc
3  disp ("The given values are ,")
4  disp ("P = 4, f = 50 Hz, R2 = 0.2 ohm, X2 = 1 ohm")
5  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")
6  disp (" Therefore ,   E_2line = 120 V, for star E_2line
        = sqrt (3)*E_2ph")
7  e2=120/sqrt (3)
```

```
 8  format (6)
 9  disp(e2,"Therefore,   E_2ph(in V) = E_2/sqrt(3) =")
10  ns=(120*50)/4
11  format (5)
12  disp(ns,"N_s(in r.p.m) = 120f/P =")
13  disp("(i) At start,")
14  cp=0.2/(sqrt((0.2^2)+1))
15  format (6)
16  disp(cp,"cos(phi) = R2/Z2 = R2 / sqrt(R2^2+X2^2) =")
17  i2=69.28/(sqrt((0.2^2)+1))
18  disp(i2,"I2(in A/phase) = E2/Z2 = E2 / sqrt(R2^2+X2
        ^2) =")
19  disp("(ii) On full load, N = 1440 r.p.m")
20  s=(1500-1440)/1500
21  format (5)
22  disp(s,"Therefore,   s = N_s-N / N_s =")
23  cpr=0.2/(sqrt((0.2^2)+(0.04^2)))
24  format (7)
25  disp(cpr,"Therefore,   cos(phi)_2r = R2/Z_2r = R2 /
        sqrt(R2^2+(s*X2)^2) =")
26  i2r=(0.04*69.28)/(sqrt((0.2^2)+(0.04^2)))
27  disp(i2r,"Therefore,   I_2r(in A) = E_2r/Z_2r = s*E2
        / sqrt(R2^2+(s*X2)^2) =")
28  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

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

```
4 disp("Stator turns/Rotor turns = 2/1")
5 disp("Therefore,   K = E2/E1 = Rotor turns/Stator
      turns = 1/2 = 0.5")
6 ns=(120*50)/4
7 format(5)
8 disp(ns,"N_s(in r.p.m) = 120f/P =")
9 disp("E_1line = 400 V              ...Stator line
      voltage given")
10 e1=400/sqrt(3)
11 format(7)
12 disp(e1,"Therefore,   E_1ph(in V) = E_1line/sqrt(3) =
      ")
13 disp("But  E_2ph/E_1ph = 0.5 = K")
14 e2=230.94/2
15 disp(e2,"Therefore,   E_2ph(in V) =")
16 s=(1500-1440)/1500
17 format(5)
18 disp(s,"Full load slip,   s = N_s-N / N_s =")
19 ns=1500/60
20 disp("n_s(in r.p.s) = Synchoronous speed in r.p.s")
21 disp(ns,"                    = N_s/60 =")
22 t=(3/(2*%pi*25))*((0.04*0.1*115.47^2)/((0.1^2)
      +(0.04^2)))
23 format(6)
24 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

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

```
 6  format (7)
 7  disp (e1 ,"E_1ph (in V) = E_1line/sqrt (3) =
        ...star connection")
 8  disp ("K = E_2ph/E_1ph = Rotor turns/stator turns =
        1/4")
 9  e2 =230.94/4
10  disp (e2 ,"Therefore ,  E_2(in V) = 1/4 * E_1ph =")
11  ns =(120*50)/4
12  format (5)
13  disp (ns ,"N_s(in r.p.m) = 120 f/P =")
14  disp ("(i) At start ,  s = 1")
15  disp ("Therefore ,  T_st = (k*E2^2*R2 / R2^2+X2^2)
              where k = 3 / 2*pi*ns")
16  ns =1500/60
17  disp (ns ,"n_s(in r.p.s) = N_s/60 =")
18  k=3/(2*%pi*25)
19  format (8)
20  disp (k ,"Therefore ,  k = 3 / 2*pi*25 =")
21  t=((0.01909*0.01*57.735^2)/((0.01^2)+(0.1^2)))
22  format (7)
23  disp (t ,"Therefore ,  T_st(in N–m) =")
24  disp ("(ii) Slip at which maximum torque occurs is ,")
25  sm =0.01/0.1
26  disp (sm ,"s_m = R2/X2 =")
27  psm =0.1*100
28  disp (psm ,"%s_m =")
29  disp ("(iii) Speed at which maximum torque occurs is
        speed corresponding to s_m ,")
30  n=1500*(1-0.1)
31  format (5)
32  disp (n ,"N(in r.p.m) = N_s*(1-s_m) =")
33  disp ("(iv) The maximum torque is ,")
34  tm =(0.01909*57.735^2)/(2*0.1)
35  format (7)
36  disp (tm ,"T_m(in N–m) = k*E2^2 / 2*X2 =")
37  disp ("(v) Full load slip , s_f = 0.04    as %s_f = 4%
        ")
38  t=((0.01909*0.04*0.01*57.735^2)/((0.01^2)+(0.004^2))
```

```
        )
39  format (7)
40  disp ( t , ” T_f . l ( in  N–m)  =( k∗s∗E2 ˆ2∗R2  /  R2ˆ2+( s _f ∗X2)
        ˆ2)  =” )
```

Scilab code Exa 5.9 find ratio of torque

```
1  // Exmaple  5.9
2  clc
3  disp ( ” Given  values  are , ” )
4  disp ( ” P  =  24 ,  f  =  50  Hz ,  R2  =  0.016  ohm ,  X2  =  0.265
       ohm ,  N  =  247  r . p .m” )
5  ns =(120∗50)/24
6  format (5)
7  disp ( ns , ” N_s ( in  r . p .m)  =  120 f /P  =” )
8  s =(250 -247)/250
9  format (6)
10  disp ( s , ” s _f  =  Full  load  slip  =  N_s–N  /  N_s  =” )
11  sm =0.016/0.265
12  format (8)
13  disp ( sm , ” s_m  =  R2/X2  =” )
14  tf =(2∗0.06037∗0.012)/((0.06037ˆ2)+(0.012ˆ2))
15  format (7)
16  disp ( tf , ” ( i )  T_F . L/T_m  =  2∗s_m∗s _f  /  s_mˆ2+s _f ˆ2  =” )
17  ts =(2∗0.06037)/((0.06037ˆ2)+(1ˆ2))
18  format (7)
19  disp ( ts , ” ( i i )  T_st /T_m  =  2∗s_m  /  1+s_mˆ2  =” )
```

Scilab code Exa 5.10 find slip

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

```
 3  disp(" The given values are ,")
 4  disp("P = 4, f = 50 Hz, T_sh = 300 N−m, T_lost = 50
        N−m")
 5  disp(" Rotor frequency = 120 cycles/min = 120/60
        cycles/sec i.e. Hz")
 6  disp(" i.e.  f_r = 2 Hz")
 7  disp("(i)  f_r = s*f")
 8  s=2/50
 9  format(5)
10  disp(s," Therefore ,  s = f_r/f =")
11  disp("(ii)  P_out = T_sh * omega = T_sh * 2*pi*N/60"
        )
12  disp("Now  N = N_s(1−s)   at slip s = 0.04")
13  ns=(120*50)/4
14  format(5)
15  disp(ns,"N_s(in r.p.m) = 120f/P =")
16  n=1500*(1-0.04)
17  disp(n," Therefore ,  N(in r.p.m) = N_s(1−s) =")
18  po=(300*((2*%pi*1440)/60))*10^-3
19  format(8)
20  disp(po," Therefore ,  P_out(in kW) =")
21  disp("Remember that T_sh is not output torque
        available to load at shaft")
22  disp("(iii)  T_lost = 50 Nm in fiction")
23  f=50*((2*%pi*1440)/60)
24  format(9)
25  disp(f," Therefore ,  Frictional loss(in W) = T_lost *
        omega = T_lost * 2*pi*N/60 =")
26  disp("Now  P_out = P_in − frictional loss")
27  pin=45.2389+7.539822
28  disp(pin," Therefore ,  P_in(in kW) = P_out +
        frictional loss =")
29  disp("  We know, P_2:P_c:P_m  is  1:s:1−s")
30  disp(" Therefore ,  P_c/P_m = s/1−s")
31  pc=(52.77872*10^3)*(0.04/(1-0.04))
32  format(10)
33  disp(pc," Therefore ,  P_c(in W) = P_m * (s/1−s) =")
34  disp(" These are total rotor copper losses")
```

```
35  rc =2199.1134/3
36  format (9)
37  disp ( rc ," Therefore ,   Rotor copper loss per phase ( in
        W) = P_c /3 =")
38  disp (" ( iv )   Rotor efficiency = ( Rotor output P_in /
        Rotor input P2 )*100" )
39  p2 =2199.1134/0.04
40  format (12)
41  disp ( p2 ,"Now  P2( in W) = P_c /s =" )
42  re =52778.72*100/54977.83
43  format (3)
44  disp ( re ," Therefore ,  % Rotor eta ( in percentage ) =")
45  disp (" ( v )  I_2r = 60 A     given per phase ")
46  disp ("now  Rotor copper loss / ph = I_2r ^2 * R2")
47  r2 =733.0378/60^2
48  format (7)
49  disp ( r2 ," Therefore ,  R2( in ohm/ ph ) =")
```

Scilab code Exa 5.11 find shaft torque

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

```scilab
        mechanical loss = 24*10^3 + 1000 =")
16  disp("For rotor P2:P_c:P_m  is  1:s:1-s")
17  disp("Therefore,  P_c/P_m = s/1-s")
18  pc=(25000)*(0.04/(1-0.04))
19  format(8)
20  disp(pc,"Therefore,  P_c(in W) = P_m * (s/1-s) =")
21  po=((24*10^3)/((2*%pi*720)/60))
22  format(8)
23  disp(po,"(i) Shaft torque  T_sh(in Nm) = P_out/omega
        = P_out / (2*pi*N/60) =")
24  t=((25*10^3)/((2*%pi*720)/60))
25  disp(t,"(ii) Gross torque T(in Nm) = P_out/omega =
        P_out / (2*pi*N/60) =")
26  disp("(iii) Rotor copper losses = 1041.66 W")
27  disp("Now  P2/P_c = 1/s")
28  p2=1041.66/0.04
29  disp(p2,"Therefore,  P2(in W) = P_c/s =")
30  pin=sqrt(3)*415*57*0.707
31  format(9)
32  disp(pin,"And net input  P_in(in W) = sqrt(3)*V_L*
        I_L*cos(phi) =")
33  disp("Stator current per phase = I_L = 57 A  (as
        star connected)")
34  disp("R_s = Stator resistance per phase  = 0.1 ohm")
35  st=3*(57^2)*0.1
36  format(6)
37  disp(st,"Therefore,  Stator copper losses(in W) = 3*
        I_s^2*R_s")
38  disp("Now  P_in - Stator losses = P_2")
39  sl=28966.96-26041.5
40  format(8)
41  disp(sl,"Therefore,  Stator losses(in W) =")
42  disp("But  Stator losses = Stator iron loss + Stator
        copper loss")
43  stp=2925.46-974.7
44  disp(stp,"Therefore,  Stator iron losses(in W) =")
45  disp("(iv)  Stator copper losses = 974.7 W")
46  disp("(v) Stator iron losses = 1950.76 W")
```

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

Scilab code Exa 5.15 `find starting torque`

```
 1  //Example 5.15
 2  clc
 3  disp("P = 12, f = 50 Hz, R2 = 0.15 ohm, X2 = 0.25
        ohm, E2 = 32 V per phase given")
 4  disp("Now  T =  (k*s*E2^2*R2 / R2^2+s*X2^2)
        where k = 3 / 2*pi*ns")
 5  ns =(120*50)/12
 6  format(4)
 7  disp(ns ,"N_s(in r.p.m) = 120f/P =")
 8  ns =500/60
 9  format(5)
10  disp(ns ,"n_s(in r.p.s) = N_s/60 =")
11  tf=(3/(2*%pi*8.33))*((0.15*32^2)/((0.15^2)+(0.25^2))
        )
12  format(7)
13  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) =")
14  disp("(ii) At  N = 480 r.p.m")
15  s=(500-480)/500
16  format(5)
17  disp(s ,"s = N_s-N / N_s =")
18  tfi =(3/(2*%pi*8.33))*((0.04*0.15*32^2)/((0.15^2)
        +((0.04*0.25)^2)))
19  format(7)
20  disp(tfi ,"Therefore ,  T_F.L(in Nm) = (3/2*pi*ns)*(s*
        E2^2*R2 / R2^2+s*X2^2) =")
21  disp("(iii)  T_m = (3/2*pi*ns)*(E2^2 / 2*X2)
        substituting s_m = R2/X2")
```

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

Scilab code Exa 5.18 find speed of motor

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

Scilab code Exa 5.19 find rotor input

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

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

Scilab code Exa 5.22 `find speeds`

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

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

Scilab code Exa 5.23 `find resistance`

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

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

Chapter 6

Instruments

Scilab code Exa 6.1 `deflection`

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

Scilab code Exa 6.2 `theta`

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

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

Scilab code Exa 6.3 `shunt resistance`

```
1  //example6.3
2  clc
3  disp("Given values are , (R_m)=100 ohm, (I_m)=2 mA, I
       =150 mA")
4  disp("(R_sh)=[(I_m)*(R_m)]/[I-(I_m)]")
5  r=(2*100*10^-3)/((150*10^-3)-(2*10^-3))
6  format(6)
7  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`

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

```
5  i=(400*10^-3)/0.01
6  disp(i,"Therefore, I_sh(in A)=(400*10^−3)/0.01= ")
7  disp("b) The voltage across shunt for shunted
       current of 50 A is,")
8  v=50*0.01
9  disp(v,"V_sh(in V)=[(I_sh)*(R_sh)]=50*0.01=")
10 disp("For this voltage the meter should give full
       scale deflection. In first case, the current
       through meter for full deflection was,")
11 i=(400*10^-3)/750
12 disp(i,"I_m(in A)=(400mV)/(R_m)=(400*10^−3)/750=")
13 disp("The same I_m must flow for new voltage across
       the meter of 0.5 V")
14 disp("Therefore, [(I_m)*(R_m)'']=0.5")
15 disp("Therefore, [(5.33*10^−4)*(R_m)'']=0.5")
16 r=0.5/(5.33*10^-4)
17 disp(r,"Therefore, (R_m'')[in ohm]=")
18 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`

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

Scilab code Exa 6.6 `shunt required and multiplier required`

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

Scilab code Exa 6.7 `voltage induced`

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

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

Scilab code Exa 6.8 `resistance`

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

Scilab code Exa 6.9 `ammeter and voltmeter`

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

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

Scilab code Exa 6.10 number of turns

```
1  //example6.10
2  clc
3  disp("R_m=2000 ohm, V_m=100 V, N=10000")
4  i=100/2000
5  disp(i,"Therefore, I_m(in A)=(V_m)/(R_m)=100/2000=")
6  i=0.05*10000
7  disp(i,"Therefore, AT for full scale deflection = (
       I_m)*N=0.05*10000")
8  disp("For I=20 A, AT=I*N''")
9  disp("Therefore, 500=20*N''")
10 n=500/20
11 disp(n,"Therefore, N''=")
```

Scilab code Exa 6.11 shunt resistance and full scale deflection

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

```
10  disp(" ii ) V=250 V")
11  r=(100/(15*10^-3))-5
12  disp(r,"R_s(in ohm)=V/I_m - R_mT =")
13  disp("Now at 25 degree celcius, (R_m)'' is the new
        meter resistance.")
14  disp("R_m'' = R_m[1+(alpha_1)*(t2-t1)] where t1=15
        degree celcius, t2=25 degree celcius")
15  a=(1/234.5)/(1+(15/234.5))
16  format(6)
17  disp(a,"(alpha_1)[in per degree celcius]=(alpha_0)
        /(1+[(alpha_0)*t1])=(1/234.5)/(1+(15/234.5))=")
18  r=1.5*(1+(0.004*(25-15)))
19  format(8)
20  disp(r,"Therefore, R_m''(in ohm)
        =1.5*(1+(0.004*(25-15)))= ")
21  r=1.56012+3.5
22  format(8)
23  disp(r,"Therefore, R_mT''(in ohm)=1.56012+3.5=")
24  disp("Error in part(i) : The Fig. 6.19 shows two
        cases.")
25  disp("Therefore, I_m1 at 15 degree celcius = (I*R_sh
        )/[(R_sh+(R_mT))]=7.4999*10^-4 I")
26  disp("Therefore, I_m2 at 25 degree celcius = (I*R_sh
        )/[(R_sh+(R_mT''))]=7.41092*10^-4 I")
27  i=((7.41092*10^-2)-(7.4999*10^-2))/(7.4999*10^-4)
28  format(7)
29  disp(i,"% error = [(I_m2)-(I_m1)*100]/(I_m1)= ")
30  disp("Negative sign indicates that the reading is
        less than the actual reading.")
31  disp("Error in part(ii) : The Fig. 6.19 shows two
        cases.")
32  disp("Therefore, V_m1 = (V*R_mT)/(R_mT+R_s)=(5*V)
        /(5+16661.67)=2.9999*10^-4 V")
33  disp("Therefore, V_m2 = (V*R_mT'')/(R_mT''+R_s)
        =(5.06012*V)/(5.06012+16661.67)=3.03606*10^-4 V")
34  v=((3.03606*10^-2)-(2.9999*10^-2))/(2.9999*10^-4)
35  format(7)
36  disp(v,"% error = [(V_m2)-(V_m1)*100]/(V_m1)= ")
```

Chapter 7

Semiconductor Physics and Diode

Scilab code Exa 7.1 forbidden gap

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

Scilab code Exa 7.2 resistivity

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

Scilab code Exa 7.3 `current in the bar`

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

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

Scilab code Exa 7.4 `resistivity of intrinsic germanium`

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

Scilab code Exa 7.7 `comparing two values`

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

```
4 disp("For 10^8 germanium atom there is 1 atom
      impurity added, as given.")
5 disp("Thus, for 4.4*10^22 germanium atoms, we have,"
      )
6 disp("        = 4.4*10^22 / 10^8 = 4.4*10^14 atoms of
      impurity/cm^3")
7 disp("This is nothing but concentration of donor
      atoms i.e. N_D")
8 disp("Therefore,  N_D = 4.4*10^14 per cm^3 =
      4.4*10^14/10^-6 = 4.4*10^20 per m^3")
9 disp("Now as donor impurity is added, n-type
      material will form,")
10 disp("Therefore,   sigma_n = n_n*u_n*q = N_D*u_n*q")
11 disp("where  n_n ~ N_D and u_n = 3800 cm^2/V-sec =
      3800*10^-4 m^2/V-sec")
12 sigm=4.4*3800*1.6*10^-3
13 format(7)
14 disp(sigm,"Therefore,   sigma_n(in per ohm-m) =")
15 rho=(1/26.752)*10^2
16 format(5)
17 disp(rho,"Therefore,   rho_n(in ohm-cm) = Resistivity
      = 1/sigma_i =")
18 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`

```
1 //Example 7.9
2 clc
```

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

Scilab code Exa 7.10 forward bias current

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

Scilab code Exa 7.11 reverse saturation current and eta for diode

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

Scilab code Exa 7.12 reverse saturation current and forward current

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

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

Scilab code Exa 7.14 `dc output voltage`

```
1  //Example 7.14
2  clc
3  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.")
4  disp("(a) For an ideal diode, cut-in voltage V_T =
      0, R_T = 0")
5  dc=-(15/%pi)
6  format(5)
7  disp(dc,"D.C. output voltage(in V) = -Maximum value
      of a.c. input voltage / pi =")
8  disp("Negative sign indicates that voltage is
      negative w.r.t ground.")
9  disp("(b) For a silicon diode, V_T = 0.7 V, R_f is
      assumed to be zero")
10  dc1=-((15-0.7)/%pi)
11  format(5)
12  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

```
1  //Example 7.15
2  clc
3  disp("Given values are R_L = 1 k-ohm, V_m = 10 V
      peak")
4  disp("case(i) Ideal diode")
5  disp("Cut-in voltage V_T = 0 V, R_f = 0 ohm")
6  edc=10/%pi
7  format(5)
8  disp(edc,"Therefore, E_DC(in V) = V_m/pi =")
9  idc=3.18
10 disp(idc,"Therefore, I_DC(in mA) = E_DC/R_L =")
11 disp("case(ii) Silicon diode")
12 disp("Cut-in voltage V_T = 0.7 V")
13 edc=9.3/%pi
14 format(5)
15 disp(edc,"Therefore, E_DC(in V) = V_m-V_T / pi =")
16 idc=2.96
17 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 second

```
1  //example7.17
2  clc
3  disp("Given: E_s=30 V, R_f=2 ohm, R_s=8 ohm, R_L=1 k
      -ohm")
4  disp("E_s=E_RMS=30 V")
5  e=30*sqrt(2)
6  disp(7)
7  disp(e,"E_sm(in V)=(E_s)*sqrt(2)=")
8  i=(30*sqrt(2))/(2+1000+8)
```

```
9  format(6)
10 disp(i,"I_m(in A)=(E_sm)/(R_f+R_L+R_s)=")
11 i=(2*42)/(%pi)
12 format(6)
13 disp(i,"I_DC(in mA)=(2*I_m)/pi=")
14 p=1000*(26.74*10^-3)^2
15 disp(p,"a) Power delivered to the load = (I_DC^2)*(
      R_L) = ")
16 v=(2*30*sqrt(2))/(%pi)
17 format(3)
18 disp(v,"V_DC, no load = (2*E_sm)/pi = ")
19 v=26.74*1000*10^-3
20 format(6)
21 disp(v,"V_DC, full load (in V) = (I_DC)*R_L = ")
22 r=((27-26.74))/26.74
23 format(5)
24 disp(r,"% Regulation = ((V_NL−V_FL)*100)/(V_FL)= ")
25 e=(8/(%pi)^2)*(1/(1+(10/1000)))
26 format(6)
27 disp(e,"c) Efficiency of rectification = dc output/
      ac output =")
28 t=(30*42*10^-3)/sqrt(2)
29 format(5)
30 disp(t,"d) Transformer secondary rating(in W) = (
      E_RMS)*(I_RMS) = ")
31 u=0.715/0.89
32 disp(u,"TUF = DC power output/AC rating = ")
```

Scilab code Exa 7.20 `ac input power`

```
1 //example7.20
2 clc
3 disp("P_DC=500 W, Half wave rectifier")
4 disp("For half wave rectifier, %eta=40.6%      ...(
      Assuming maximum)")
```

```
 5  disp("Therefore, 40.6=(P_DC*100)/(P_AC)")
 6  disp("Therefore, 40.6=(500*100)/(P_AC)")
 7  p=(500*100)/(40.6)
 8  format(9)
 9  disp(p,"Therefore, P_AC(in W)=")
10  disp("For the same load, with full wave rectifier
         the maximum rectifier efficiency is 81.2%")
11  disp("Therefore, 81.2=(500*100)/(P_AC)")
12  p=(500*100)/81.2
13  format(10)
14  disp(p,"Therefore, P_AC(in W)=")
```

Scilab code Exa 7.21 `percentage eta`

```
 1  //example7.21
 2  clc
 3  disp("The given values are,")
 4  disp("R_f=0.1 ohm, I_DC=10 A, R_s= 0 ohm, E_s(RMS)
         =30 V")
 5  e=30*sqrt(2)
 6  format(8)
 7  disp(e,"Now, (E_sm)=E_sm(RMS)*sqrt(2) =")
 8  disp("(I_DC)=(2*I_m)/pi")
 9  i=(%pi*10)/2
10  disp(i,"I_m(in A)=(pi*I_DC)/2=")
11  disp("Now, (I_m)=(E_m)/(2*R_f+R_s+R_L)")
12  disp("Therefore, 15.7079 = 42.4264/(2*0.1+R_L)")
13  disp("Therefore, R_L+0.2=2.7")
14  r=2.7-0.2
15  disp(r,"Therefore, R_L(in ohm)=")
16  p=(10^2)*2.5
17  disp(p,"P_DC(in W)=(I_DC^2)*R_L=")
18  disp("P_AC = (I_RMS^2)*(2*R_f+R_s+R_L)")
19  i=15.7079/sqrt(2)
20  disp(i,"and, (I_RMS)[in A]=(I_m)/sqrt(2)=")
```

```
21  p=(11.1071^2)*(0.2+2.5)
22  disp(p,"Therefore, (P_AC)[in W]=")
23  e=(250*100)/333.092
24  disp(e,"% eta=(P_DC*100)/(P_AC)=")
```

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

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

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Scilab code Exa 7.23 `load voltage and ripple voltage`

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

Scilab code Exa 7.25 `dc output voltage`

```
1  //example7.25
2  clc
3  disp("For a half wave rectifier,")
4  disp("(I_m) = (E_sm)/(R_f+R_L)")
```

```
5  disp("and, (I_DC) = (I_m)/pi = (E_sm)/pi*(R_f+R_L)")
6  disp("and, (V_DC) = (I_DC)*(R_L)")
7  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)")
8  disp("For this power to be maximum,")
9  disp("(dP_DC)/(dR_L) = 0")
10 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")
11 disp("Therefore,  (R_f+R_L)^2 - 2*R_L*(R_f+R_L) = 0"
       )
12 disp("Therefore,  (R_f^2)-(R_L^2) = 0")
13 disp("Therefore,  (R_L)^2 = (R_f)^2     i.e.      R_L
       = R_f")
14 disp("Thus the power output is maximum if R_L = R_f"
       )
```

Scilab code Exa 7.29 `forward current`

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

Scilab code Exa 7.30 `temperature`

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

Scilab code Exa 7.31 `conductivity of silicon`

```
1 //example7.31
2 clc
3 disp("As the impurity is accepter , it forms a p-type
       material .")
4 disp("Therefore , N_A = 10^22 /m^3 = p_p")
5 disp("Now, (p_p)*(n_p)=(n_i)^2      i.e.     (10^22)*(
      n_p)=(1.4*10^16)^2")
6 n=((1.4*10^16)^2)/(10^22)
7 disp(n,"Therefore , n(in /m^3)= ")
8 r=((1.96*0.145*10^10)+(0.05*10^22))*(1.6*10^-19)
9 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`

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

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

```
 5  format (7)
 6  disp(b,"For, (beta_dc)=50, (alpha_dc)=50/(1+50)=")
 7  b=190/191
 8  disp(b,"For, (beta_dc)=190, (alpha_dc)=190/(1+190)="
       )
 9  disp("b) (beta_dc)=(alpha_dc)/(1-(alpha_dc))")
10  a=0.995/(1-0.995)
11  disp(a,"For, (alpha_dc)=0.995, (beta_dc)
       =0.995/(1-0.995)=")
12  a=0.9765/(1-0.9765)
13  format(6)
14  disp(a,"For, (alpha_dc)=0.9765, (beta_dc)
       =0.9765/(1-0.9765)=")
```

Scilab code Exa 8.3 `collector current`

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

Scilab code Exa 8.4 `alpha dc and beta dc`

```
1  //example8.4
2  clc
3  disp("Given: I_CO=1.1 uA, I_E=21 uA")
4  disp("I_CEO=(1+(beta_dc))*(I_CO)")
5  disp("1+(beta_dc)=(I_CEO).(I_CO)=(21 uA)/(1.1 uA)=19
      ")
6  b=19-1
7  disp(b,"Therefore, (beta_dc)=")
8  a=18/19
9  format(6)
10 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`

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

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

Scilab code Exa 8.8 firing angle

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

Scilab code Exa 8.9 time for SCR remains off

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

```
11  d=(22.619*%pi)/180
12  format(7)
13  disp(d,"Therefore, alpha=(22.619*pi)/180 radian=")
14  t=0.3947/(100*%pi)
15  format(8)
16  disp(t,"Therefore, Time of alpha(in sec)=alpha/w
        =0.3947/(100*pi)=")
17  disp("For this period SCR remains OFF in positive
        half cycle.")
18  disp("While for entire negative half cycle i.e. for
        pi radians (180 degree) it remains OFF. Thus
        corresponding time is (angle/w)")
19  a=1/100
20  disp(a,"i.e. pi/(100*pi)[in sec]= ")
21  t=10+1.25
22  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`

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

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```
16  disp ( " i i ) When electron reaches to second plate, x
        =2*10^ −2 m")
17  disp ( " Therefore , x=(1/2)*( a_x )*t ^2" )
18  disp ( " Therefore , 2*10^ −2 = (1/2)*(8.7844*10^13)*t^2"
        )
19  disp ( " Therefore , t ^2 = 4.5535*10^ −16" )
20  t=sqrt (4.5535*10^-16)
21  format (15)
22  disp (t ," Therefore , t ( in sec )=")
```

Scilab code Exa 9.2 `final velocity pf electron`

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

Scilab code Exa 9.4 `velocity and deflection and deflection sensitivity`

```
1  //example9.4
2  clc
3  disp ( " d=1 cm, L=33 cm, l =4.5 cm, (V_a )=300 V, (V_d)
        =50 V")
4  v=sqrt ((2*1.6*300*10^-19)/(9.107*10^-31))
5  format (9)
6  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))=")
7  d=((4.5*10^-2)*(33*10^-2)*50)/(2*300*10^-2)
8  format (7)
```

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

Scilab code Exa 9.7 speed of electron and force on electron

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

Scilab code Exa 9.8 amplitude and rms value

```
1   //example9.8
2   clc
```

```
3  disp("It can be observed that the screen is divided
      such that one part is subdivided into 5 units.")
4  disp("Therefore, 1 subdivision = 1/5 = 0.2 units")
5  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.")
6  v=2.6+2.6
7  disp(v,"Therefore, (V_pp)[in divisions]=Peak to peak
      =2.6+2.6=")
8  v=5.2*2*10^-3
9  disp(v,"Therefore, (V_pp)[in V]=Number of divisions*
      volts/divisions= ")
10 a=10.4/2
11 disp(a,"Therefore, (V_m)[in mV]=Amplitude=(V_pp)/2="
      )
12 v=5.2/(sqrt(2))
13 format(8)
14 disp(v,"and, (V_RMS)[in mV]= (V_m)/sqrt(2)= ")
```

Scilab code Exa 9.10 `phase difference`

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

Scilab code Exa 9.11 unknown frequency of vertical signal

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

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

```
1  //example9.12
2  clc
3  disp("d=0.5 cm, L=20 cm, l=2 cm, (V_a)=1000 V, (V_d)
       =25 V")
4  d=((2*10^-2)*(20*10^-2)*25)/(2*0.5*1000*10^-2)
5  disp(d,"i) D(in m)=(l*L*(V_d))/(2*d*V_a)=")
6  s=0.01/25
7  disp(s,"Therefore, S(in m/V)=D/(V_d)=")
8  disp("ii) tan(theta)=(l*a_y)/(v_ox^2)")
9  a=((1.6*10^-19)*25)/((0.5*10^-2)*(9.107*10^-31))
10 format(9)
11 disp(a,"where, a_y(in m/s^2)=(q*v_d)/(d*m)= ")
12 v=sqrt((2*1.6*1000*10^-19)/(9.107*10^-31))
13 disp(v,"v_ox(in m/s)=sqrt((2*q*V_a)/m)=")
14 t=((2*10^-2)*(8.7844*10^14))/((18.745*10^6)^2)
15 format(5)
16 disp(t,"Therefore, tan(theta)=t=((2*10^-2)
       *(8.7844*10^14))/((18.745*10^6)^2)= ")
17 a=atand(0.05)
```

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```
18  format (6)
19  disp(a,"Therefore, theta(in degree)= ")
20  format (9)
21  disp(v,"iii) (v_ox)= Velocity of electrons −
        Velocity of beam =")
```

Scilab code Exa 9.15 `time for electron`

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

Scilab code Exa 9.16 `deflection sensitivity`

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

```
4  disp("S=D/(V_d)=(l*L)/(2*d*V_a) m/V        ... Defection
       sensitivity")
5  disp("i) V_a=1000 V")
6  s=((2*10^-2)*(25*10^-2))/(2*4*1000*10^-3)
7  disp(s,"Therefore, S(in m/V)=((2*10^-2)*(25*10^-2))
       /(2*4*1000*10^-3)= ")
8  disp("ii) V_a=2000 V")
9  s=((2*10^-2)*(25*10^-2))/(2*4*2000*10^-3)
10 disp(s,"Therefore, S(in m/V)=((2*10^-2)*(25*10^-2))
       /(2*4*2000*10^-3)= ")
11 disp("iii) V_a=3500 V")
12 s=((2*10^-2)*(25*10^-2))/(2*4*3500*10^-3)
13 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`

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

Scilab code Exa 9.18 `input voltage`

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

Scilab code Exa 9.19 `beam velocity and deflection sensitivity and deflection facto`

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