

Scilab Textbook Companion for
Electronic Devices
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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 2

Energy Bands And Charge Carriers in Semiconductor

Scilab code Exa 2.1 Energy gap

```
1 // Exa 2.1
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 lambda = 11000; // in
8 lambda = lambda * 10^-10; // in m
9 h = 6.625*10^-34; // Planck constant
10 c = 3*10^8; // speed of light in m/s
11 e = 1.6*10^-19; // charge of electron in C
12 // Energy of the incident photon should at least be,
    h*v= Eg, so
13 E_g = (h*c)/(lambda*e); // in eV
14 disp(E_g,"The energy gap in eV is");
```

Scilab code Exa 2.2 Wavelength

```
1 // Exa 2.2
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 E_g = 0.75; // in eV
8 e = 1.6*10^-19; // in C
9 h = 6.63*10^-34; // in J
10 c = 3*10^8; // in m/s
11 //Formula E_g = (h*c)/(lambda*e);
12 lambda = (h*c)/(E_g*e); // in m
13 lambda = lambda * 10^10; // in
14 disp(lambda,"The wavelength in      is");
```

Scilab code Exa 2.3 Position of Fermi level

```
1 //Exa 2.3
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 del_E = 0.3; // in eV
8 T1 = 300; // in K
9 T2 = 330; // in K
10 // del_E = K * T1 * log(N/N_c) where del_E= E_C-E_F
11 // del_E1 = K * T2 * log(N/N_c) where del_E1= E_C-
    E_F at T= 330 K
12 del_E1 = del_E*(T2/T1); // in eV
13 disp("The Fermi level will be "+string(del_E1)+" eV
    below the conduction band")
```

Scilab code Exa 2.4 Probability

```
1 //Exa 2.4
2 clc;
3 clear;
4 close;
5 format('e',8)
6 // Given data
7 N_c = 2.8 * 10^19; // in cm^-3
8 del_E = 0.25; // fermi energy in eV
9 KT = 0.0259; // where K is Boltzmann constant
10 f_F = exp(-(del_E)/KT);
11 disp(f_F,"The probability in the conduction band is
    occupied by an electron is ");
12 // Evaluation of electron concentration
13 n_o = N_c * exp(-(del_E)/KT); // in cm^-3
14 disp(n_o,"The thermal equilibrium electron
    concentration in cm^-3 is");
```

Scilab code Exa 2.5 Thermal equilibrium hole concentration

```
1 //Exa2.5
2 clc;
3 clear;
4 close;
5 format('v',9)
6 // Given data
7 T1 = 300; // in K
8 T2 = 400; // in K
9 del_E = 0.27; // Fermi level in eV
10 KT = (0.0259) * (T2/T1); // in eV
11 N_v = 1.04 * 10^19; // in cm^-3
```

```

12 N_v = N_v * (T2/T1)^(3/2); // in cm^-3
13 // Hole concentration
14 p_o = N_v * exp(-(del_E)/KT); // in per cm^3
15 disp(p_o,"The thermal equilibrium hole concentration
per cm^3 is");

```

Scilab code Exa 2.6 Mobility of electrons in copper

```

1 // Exa 2.6
2 clc;
3 clear;
4 close;
5 format('v',7)
6 // Given data
7 At = 63.5; // atomic weight
8 Rho = 1.7*10^-6; // in ohm cm
9 d = 8.96; // in gm/cc
10 N_A = 6.02*10^23; // in /gm.mole
11 e = 1.6*10^-19; // in C
12 //Number of atoms of copper percent per unit volume
13 n = (N_A/At)*d;
14 Miu_e = 1/(Rho*n*e); // in cm^2/volt.sec
15 disp(Miu_e,"The electron mobility in cm^2/volt-sec
is");

```

Scilab code Exa 2.7 Density of free electrons

```

1 // Exa 2.7
2 clc;
3 clear;
4 close;
5 format('v',9)
6 // Given data

```

```

7 l = 0.1; // in m
8 A = 1.7; // in mm^2
9 A = A * 10^-6; // in m^2
10 R = 0.1; // in ohm
11 At = 63.5; // atomic weight
12 N_A = 6.02*10^23;
13 d = 8.96; // in gm/cc
14 n = (N_A/At)*d; // in /cc
15 n = n * 10^6; // in /m^3
16 e = 1.6*10^-19; //electron charge in C
17 // Resistivity of copper
18 //Formula R = Rho*(l/A);
19 Rho = (R*A)/l; // in ohm m
20 // Conductivity of copper
21 Sigma = 1/Rho; // in mho/m
22 // Formula Sigma = n*e*Miu_e
23 Miu_e = Sigma/(n*e); // in m^2/V.sec
24 disp(Miu_e,"The mobility in m^2/V-sec is");

```

Scilab code Exa 2.8 Drift velocity

```

1 // Exa 2.8
2 clc;
3 clear;
4 close;
5 format('v',7)
6 // Given data
7 d = 10.5; // in gm/cc
8 At = 108; // atomic weight
9 N_A = 6.025*10^23; // in /gm mole
10 r = 10^-3; // in m
11 q = 1.6*10^-19; // in C
12 // The number of electrons per unit volume
13 n = (N_A/At)*d; // in /cm^3
14 n = n * 10^6; // in /m^3

```

```

15 A = %pi*((r)^2); // in m^2
16 I = 2; // in A
17 // Evaluation of drift velocity with the help of
    current
18 // I = q*n*A*V;
19 V = I/(n*q*A); // in m/s
20 disp(V,"The drift velocity in m/s is");
21
22 // Note: Calculation in the book is wrong, so the
    answer in the book is wrong.

```

Scilab code Exa 2.9 Mobility of charge carriers

```

1 // Exa 2.9
2 clc;
3 clear;
4 close;
5 format('v',8)
6 // Given data
7 d = 1.03; // in mm
8 d = d *10^-3; // in m
9 r = d/2; // in m
10 R = 6.51; // in ohm
11 l = 300; // in mm
12 e = 1.6*10^-19; // electron charge in C
13 n = 8.4*10^28; // in /m^3
14 A = %pi*r^2; // cross section area
15 //Formula R = Rho*(l/A);
16 Rho = (R* A)/l; //in ohm m
17 Sigma = 1/Rho; // in mho/m
18 disp(Sigma,"The conductivity of copper in mho/m is")
    ;
19 // Evaluation of mobility
20 //Formula sigma = n*e*Miu_e
21 Miu_e = Sigma/(n*e); // in m^2/V.sec

```

```
22 disp(Miu_e,"The mobility in m2/V-sec is");
```

Scilab code Exa 2.10 Conductivity of pure Si

```
1 // Exa 2.10
2 format('v',8)
3 clc;
4 clear;
5 close;
6 // Given data
7 Mu_e = 1500;// in cm2/volt sec
8 Mu_h = 500;// in cm2/volt sec
9 n_i = 1.6 * 1010;// in per cm3
10 e = 1.6 * 10-19;// in C
11 // The conductivity of pure semiconductor
12 Sigma = n_i * (Mu_e + Mu_h) * e;// in mho/cm
13 disp(Sigma,"The conductivity of pure semiconductor
    in mho/cm is");
```

Scilab code Exa 2.11 Number of donor atoms

```
1 // Exa 2.11
2 format('v',9)
3 clc;
4 clear;
5 close;
6 // Given data
7 Rho = 10;// in -cm
8 Mu_d = 500;// in cm2/v.s.
9 e = 1.6*10-19;// electron charge in C
10 // The number of donor atom
11 n_d = 1/(Rho * e * Mu_d);// in per cm3
12 disp(n_d,"The number of donor atom per cm3 is ");
```

Scilab code Exa 2.12 Conductivity of specimen

```
1 //Exa 2.12
2 format('v',6)
3 clc;
4 clear;
5 close;
6 //Given data
7 AvagadroNumber = 6.02 * 10^23; // in atoms/gm.mole
8 at_Ge = 72.6; // atom weight of Ge
9 e = 1.6 * 10^-19; // in C
10 D_Ge = 5.32; // density of Ge in gm/c.c
11 Mu = 3800; // in cm^2/v.s.
12 C_Ge = (AvagadroNumber/at_Ge) * D_Ge; //
    concentration of Ge atoms in per cm^3
13 n_d = C_Ge/10^8; // in per cc
14 Sigma = n_d * Mu * e; // in mho/cm
15 disp(Sigma,"The conductivity in mho/cm is");
```

Scilab code Exa 2.13 Mobility of electrons in Ge

```
1 // Exa2.13
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 Rho = 0.3623 * 10^-3; // in Ohm m
8 Sigma = 1/Rho; //in mho/m
9 D = 4.42 * 10^28; // Ge density in atom/m^3
10 n_d = D / 10^6; // in atom/m^3
```



```

11 e = 1.6 * 10^-19; // in C
12 // The mobility of electron in germanium
13 Mu = Sigma/(n_d * e); // in m^2/V.sec
14 disp(Mu,"The mobility of electron in germanium in m
      ^2/V.sec is");

```

Scilab code Exa 2.14 Density and mobility of holes

```

1 //Exa 2.14
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 AvagadroNumber = 6.025 * 10^26; // in kg.Mole
8 W = 72.59; // atomic weight of Ge
9 D = 5.36 * 10^3; //density of Ge in kg/m^3
10 Rho = 0.42; // resistivity in Ohm m
11 e = 1.6 * 10^-19; // in C
12 Sigma = 1/Rho; // in mho/m
13 n = (AvagadroNumber/W) * D; // number of Ge atoms
      present per unit volume
14 // Holes per unit volume, H = n*10^-6%
15 H= n*10^-8;
16 a=H;
17 // Formula sigma= a*e*Mu.h
18 Mu_h = Sigma/(a * e); // in m^2/V.sec
19 disp(Mu_h,"Mobility of holes in m^2/V.sec is");

```

Scilab code Exa 2.15 Current produced

```

1 //Exa 2.15
2 format('v',5)

```

```

3  clc;
4  clear;
5  close;
6  // Given data
7  e = 1.6 * 10^-19; // in C
8  n_i = 2 * 10^19; // in /m^3
9  Mu_e = 0.36; // in m^2/v.s
10 Mu_h = 0.17; // in m^2/v.s
11 A = 1 * 10^-4; // in m^2
12 V = 2; // in volts
13 l = 0.3; // in mm
14 l = l * 10^-3; // in m
15 E=V/l; // in volt/m
16 Sigma = n_i * e * (Mu_e + Mu_h); // in mho/m
17 // J = I/A = Sigma * E
18 I= Sigma*E*A;
19 disp(I,"The current produced in a small germanium
    plate in amp is");

```

Scilab code Exa 2.16 Resistivity of doped Ge

```

1  // Exa 2.16
2  format('v',9)
3  clc;
4  clear;
5  close;
6  // Given data
7  D = 4.2 * 10^28; //density of Ge atoms per m^3
8  N_d = D / 10^6; // per m^3
9  e = 1.6 * 10^-19; // in C
10 Mu_e = 0.36; // in m^2/V-sec
11 // Donor concentration is very large as compared to
    intrinsic carrier concentration
12 Sigma_n = N_d * e * Mu_e; // in mho/m (intrinsic
    concentration can be neglected)

```

```

13 Rho_n = 1/Sigma_n; // in ohm m
14 disp(Rho_n,"The resistivity of drop Ge in ohm m is ")
    );

```

Scilab code Exa 2.17 Current produced in Ge sample

```

1 // Exa 2.17
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // given data
7 e = 1.6 * 10^-19; // in C
8 n_i = 1 * 10^19; // in per m^3
9 Mu_e = 0.36; // in m^2/volt.sec
10 Mu_h = 0.17; // in m^2/volt.sec
11 A = 2; // in cm^2
12 A = A * 10^-4; // in m^2
13 t = 0.1; // in mm
14 t = t * 10^-3; // in m
15 V = 4; // in volts
16 Sigma_i = n_i * e * (Mu_e + Mu_h); // in mho/m
17 J = Sigma_i * (V/t); // in Amp/m^2
18 // Current produced, I= J*A
19 I = J * A; // in Amp
20 disp(I,"The current produced in a Ge sample in Amp
    is");

```

Scilab code Exa 2.18 Conductivity of pure Si

```

1 //Exa 2.18
2 format('v',8)
3 clc;

```

```

4 clear;
5 close;
6 // Given data
7 e = 1.6 * 10^-19; // in C
8 Mu_h = 500; // in cm^2/V.s.
9 Mu_e = 1500; // in cm^2/V.s.
10 n_i = 1.6 * 10^10; // in per cm^3
11 // Conductivity of pure silicon at room temperature
12 Sigma_i = n_i * e * ( Mu_h + Mu_e); // in mho/cm
13 disp(Sigma_i, "Conductivity of pure silicon at room
    temperature in mho/cm is");

```

Scilab code Exa 2.19 Hall voltage produced

```

1 //Exa 2.19
2 format('v',9)
3 clc;
4 clear;
5 close;
6 //Given data
7 l= 0.50*10^-2; // width of ribbon in m
8 d= 0.10*10^-3; // thickness of ribbon in m
9 A= l*d; // area of ribbon in m^2
10 B = 0.8; // in Tesla
11 D = 10.5; //density in gm/cc
12 I = 2; // in amp
13 q = 1.6 * 10^-19; // in C
14 n=6*10^28; // number of elec. per m^3
15 V_H = ( I * B * d)/(n * q * A); // in volts
16 disp(V_H, "The hall Voltage produced in volts is");

```

Scilab code Exa 2.20 Hall coefficient and mobility of electrons

```

1 //Exa 2.20
2 format('v',8)
3 clc;
4 clear;
5 close;
6 // Given data
7 l = 1; // in m
8 d = 1; // in cm
9 d = d * 10^-2; // in m
10 W = 1; // in mm
11 W = W * 10^-3; // in m
12 A = d * W; // in m^2
13 I = 1; // in A
14 B = 1; // Tesla
15 V_H = 0.074 * 10^-6; // in volts
16 Sigma = 5.8 * 10^7; // in mho/m
17 // The hall coefficient
18 R_H = (V_H * A)/(B*I*d); // in m^3/c
19 disp(R_H,"The hall coefficient in m^3/c is");
20 // Mobility of electrons in copper
21 Mu = Sigma * R_H; // in m^2/volt-sec
22 disp(Mu,"The mobility of electrons in copper in m
    ^2/volt-sec is ");

```

Scilab code Exa 2.21 Concentration of holes in Si crystals

```

1 //Exa2.21
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 n_i = 1.4 * 10^18; // in /m^3
8 n_D = 1.4 * 10^24; // in /m^3
9 // Concentration of electrons

```

```

10 n=n_D;// in /m^3
11 p = n_i^2/n;// in /m^3
12 // The ratio of electrons to hole concentration
13 R = n/p;
14 disp(R,"The ratio of electrons to hole concentration
      is");

```

Scilab code Exa 2.22 Hall angle

```

1 //Exa 2.22
2 format('v',10)
3 clc;
4 clear;
5 close;
6 //Given data
7 R = 9 * 10^-3;// in ohm-m
8 R_H = 3.6 * 10^-4;// in m^3
9 e = 1.6 * 10^-19;// in C
10 Sigma = 1/R;// in (ohm-m)^-1
11 Rho = 1/R_H;// in coulomb/m^3
12 // Density of charge carriers
13 n = Rho/e;// in /m^3
14 disp(n,"Density of charge carriers per m^3 is");
15 // Mobility of charge carriers
16 Mu = Sigma * R_H;// in m^2/v-s
17 disp(Mu,"Mobility of charge carriers in m^2/V-s is")
      ;

```

Scilab code Exa 2.23 Current density in specimen

```

1 //Exa 2.23
2 format('v',6)
3 clc;

```

```

4 clear;
5 close;
6 // Given data
7 e = 1.6 * 10^-19; // in C
8 R_H = 0.0145; // in m^3/coulomb
9 Mu_e = 0.36; // in m^2/v-s
10 E = 100; // in V/m
11 n = 1/(e * R_H); // in /m^3
12 // The current density of specimen
13 J = n * e * Mu_e * E; // in A/m^2
14 disp(J,"The current density of specimen in A/m^2 is"
      );

```

Scilab code Exa 2.24 Relaxation time

```

1 //Exa 2.24
2 format('v',9)
3 clc;
4 clear;
5 close;
6 //Given data
7 Mu_e = 7.04 * 10^-3; // in m^2/v-s
8 m = 9.1 * 10^-31;
9 E_F = 5.5; // in eV
10 n = 5.8 * 10^28;
11 e = 1.6 * 10^-19; // in C
12 // Relaxation Time
13 Torque = (Mu_e/e) * m; // in sec
14 disp(Torque,"Relaxation Time in sec is ");
15 // Resistivity of conductor
16 Rho = 1/(n * e * Mu_e); // in ohm-m
17 disp(Rho,"Resistivity of conductor in ohm-m is ");
18 // Velocity of electrons with fermi-energy
19 V_F = sqrt((2 * E_F * e)/m); // in m/s
20 disp(V_F,"Velocity of electrons with fermi-energy in

```

```

        m/s is");
21
22 //Note: The calculated value of Resistivity of
        conductor is wrong.

```

Scilab code Exa 2.25 Temperature

```

1 //Exa 2.25
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 E= 5.95; // in eV
8 EF= 6.25; // in eV
9 delE= 0.01;
10 // delE= 1-1/(1+exp((E-EF)/KT))
11 K=1.38*10^-23; // Boltzmann Constant in J/K
12 // The temperature at which there is a 1 %
        probability that a state 0.30 eV below the Fermi
        energy level
13 T = ((E-EF)/log(1/(1-delE) -1)*1.6*10^-19)/K; // in K
14 disp(T,"The temperature in K is : ")

```

Scilab code Exa 2.26 Thermal equilibrium hole concentration

```

1 //Exa 2.26
2 format('v',9)
3 clc;
4 clear;
5 close;
6 // Given data
7 N_V = 1.04 * 10^19; // in cm^-3

```



```

8 T1 = 300; // in K
9 T2 = 400; // in K
10 del_E = 0.27; // in eV
11 // The value of N_V at T=400 K,
12 N_V = N_V * (T2/T1)^1.5; // in cm^-3
13 KT = (0.0259) * (T2/T1); // in eV
14 // The thermal equilibrium hole concentration in
    silicon
15 P_o = N_V * exp(-(del_E)/KT); // in cm^-3
16 disp(P_o, "The thermal equilibrium hole concentration
    in silicon in cm^-3 is ");

```

Scilab code Exa 2.27 Required doping concentration

```

1 //Exa 2.27
2 format('v',10)
3 clc;
4 clear;
5 close;
6 //Given data
7 N_c = 2.8 * 10^19;
8 N_V = 1.04 * 10^19;
9 T1 = 550; // in K
10 T2 = 300; // in K
11 E_g = 1.12;
12 KT = (0.0259) ;
13 n_i = sqrt(N_c * N_V * (T1/T2)^3 * exp(-(E_g)/KT*T2/T1)
    ); // in cm^-3
14 // n_o = N_d/2 + sqrt((N_d/2)^2 + (n_i)^2)
15 // 1.05*N_d - N_d/2 = sqrt((N_d/2)^2 + (n_i)^2)
16 // Minimum donor concentration required
17 N_d = sqrt((n_i)^2 / ((0.55)^2 - 1/4));
18 disp(N_d, "Minimum donor concentration required in cm
    ^-3 is");

```

Scilab code Exa 2.28 Quasi Fermi energy levels

```
1 //Exa 2.28
2 format('v',7)
3 clc;
4 clear;
5 close;
6 //Given data
7 T = 300; // in K
8 n_o = 10^15; // in cm^-3
9 n_i = 10^10; // in cm^-3
10 p_o = 10^5; // in cm^-3
11 del_n = 10^13; // in cm^-3
12 del_p = del_n; // in cm^-3
13 KT = 0.0259; // in eV
14 delta_E1= KT*log(n_o/n_i); // value of E_F-E_Fi in eV
15 delta_E2= KT*log((n_o+del_n)/n_i); // value of E_Fn-
    E_Fi in eV
16 delta_E3= KT*log((p_o+del_p)/n_i); // value of E_Fi-
    E_Fp in eV
17 disp(delta_E1,"The Fermi level for thermal
    equilibrium in eV is : ")
18 disp(delta_E2,"The quase-Fermi level for electrons
    in non equilibrium in eV is : ")
19 disp(delta_E3,"The quasi-Fermi level for holes in
    non equilibrium in eV is : ")
20 disp("The quasi-Fermi level for electrons is above
    E_Fi ")
21 disp("While the quasi-Fermi level for holes is below
    E_Fi")
```

Chapter 3

Excess Carriers In Semiconductors

Scilab code Exa 3.1 Hole concentration at equilibrium

```
1 // Exa 3.1
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 N_d = 10^17; // atoms/cm^3
8 n_i = 1.5 * 10^10; // in /cm^3
9 n_o = 10^17; // in cm^3
10 // p_o * n_o = (n_i)^2
11 p_o = (n_i)^2 / n_o; //in holes/cm^3
12 disp(p_o,"The hole concentration at equilibrium in
    holes/cm^3 is");
```

Scilab code Exa 3.3 Position of Fermi level

```

1 // Exa 3.3
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 n_i = 1.5 * 10 ^10; // in /cm^3 for silicon
8 N_d = 10^17; // in atoms/cm^3
9 n_o = 10^17; // electrons/cm^3
10 KT = 0.0259;
11 // E_r - E_i = KT * log(n_o/n_i)
12 del_E = KT * log(n_o/n_i); // in eV
13 disp("The energy band for this type material is Ei +
      "+string(del_E)+" eV");

```

Scilab code Exa 3.4 Diffusion coefficients of electrons and holes

```

1 // Exa 3.4
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 K = 1.38 * 10^-23; // in J/K
8 T = 27; // in degree
9 T = T + 273; // in K
10 e = 1.6 * 10^-19; // in C
11 Mu_e = 0.17; // in m^2/v-s
12 Mu_e1 = 0.025; // in m^2/v-s
13 D_n = ((K * T)/e) * Mu_e; // in m^2/s
14 disp(D_n,"The diffusion coefficient of electrons in
      m^2/s is");
15 D_p = ((K * T)/e) * Mu_e1; // in m^2/s
16 disp(D_p,"The diffusion coefficient of holes in m
      ^2/s is ");

```

Scilab code Exa 3.5 Diffusion length

```
1 // Exa 3.5
2 format('v',8)
3 clc;
4 clear;
5 close;
6 // Given data
7 Mu_n = 0.15; // in m^2/v-s
8 K = 1.38 * 10^-23; // in J/K
9 T = 300; // in K
10 del_n = 10^20; // in per m^3
11 Toh_n = 10^-7; // in s
12 e = 1.6 * 10^-19; // in C
13 D_n = Mu_n * ((K * T)/e); // in m^2/s
14 disp(D_n,"The diffusion coefficient in m^2/s is");
15 L_n = sqrt(D_n * Toh_n); // in m
16 disp(L_n,"The Diffusion length in m is");
17 J_n = (e * D_n * del_n)/L_n; // in A/m^2
18 disp(J_n,"The diffusion current density in A/m^2 is"
);
19 // Note : The value of diffusion coefficient in the
    book is wrong.
```

Scilab code Exa 3.6 Concentration of holes and electrons

```
1 // Exa 3.6
2 format('v',8)
3 clc;
4 clear;
5 close;
```

```

6 // Given data
7 Sigma = 0.1; // in (ohm-m)^-1
8 Mu_n = 1300;
9 n_i = 1.5 * 10^10;
10 q = 1.6 * 10^-19; // in C
11 n_n = Sigma/(Mu_n * q); // in electrons/cm^3
12 n_n = n_n * 10^6; // per m^3
13 disp(n_n, "The concentration of electrons per m^3 is"
    );
14 p_n = (n_i)^2/n_n; // in per cm^3
15 p_n = p_n * 10^6; // in per m^3
16 disp(p_n, "The concentration of holes per m^3 is");

```

Scilab code Exa 3.7 Electron transit time

```

1 // Exa 3.7
2 format('v',9)
3 clc;
4 clear;
5 close;
6 // Given data
7 Mu_e = 0.13; // in m^2/v-s
8 Mu_h = 0.05; // in m^2/v-s
9 Toh_h = 10^-6; // in s
10 L = 100; // in m
11 L = L * 10^-6; // in m
12 V = 2; // in V
13 t_n = L^2/(Mu_e * V); // in s
14 disp(t_n, "Electron transit time in seconds is");
15 p_g = (Toh_h/t_n) * (1 + Mu_h/Mu_e); //photo
    conductor gain
16 disp(p_g, "Photo conductor gain is");
17
18 // Note: There is a calculation error to evaluate
    the value of t_n. So the answer in the book is

```

wrong

Scilab code Exa 3.8 Resistivity of intrinsic Ge

```
1 // Exa 3.8
2 format('v',5)
3 clc;
4 clear;
5 close;
6 //Given data
7 n_i = 2.5 * 10^13;
8 Mu_n = 3800;
9 Mu_p = 1800;
10 q = 1.6 * 10^-19; // in C
11 Sigma = n_i * (Mu_n + Mu_p) * q; // in (ohm-cm)^-1
12 Rho = 1/Sigma; // in ohm-cm
13 Rho= round(Rho);
14 disp(Rho,"The resistivity of intrinsic germanium in
    ohm-cm is");
15 N_D = 4.4 * 10^22/(1*10^8); // in atoms/cm^3
16 Sigma_n = N_D * Mu_n * q; // in (ohm-cm)^-1
17 Rho_n = 1/Sigma_n; // in ohm-cm
18 disp(Rho_n,"If a donor type impurity is added to the
    extent of 1 atom per 10^8 Ge atoms, then the
    resistivity drops in ohm-cm is");
```

Scilab code Exa 3.9 Hole and electron concentration

```
1 // Exa 3.9
2 format('v',8)
3 clc;
4 clear;
5 close;
```

```

6 // Given data
7 n_i = 10^16; // in /m3
8 N_D = 10^22; // in /m^3
9 n = N_D; // in /m^3
10 disp(n, "Electron concentration per m^3 is");
11 p = (n_i)^2/n; // in /m^3
12 disp(p, "Hole concentration per m^3 is");

```

Scilab code Exa 3.10 Ratio of donor atoms to Si atom

```

1 // Exa 3.10
2 format('v',8)
3 clc;
4 clear;
5 close;
6 // Given data
7 Rho = 9.6 * 10^-2; // in ohm-m
8 Sigma_n = 1/Rho; // in (ohm-m)^-1
9 q = 1.6 * 10^-19; // in C
10 Mu_n = 1300 * 10^-4; // in m^2/V-sec
11 N_D = Sigma_n / (Mu_n * q); // in atoms/m^3
12 A_D = 5*10^22; // Atom density in atoms/cm^3
13 A_D = A_D * 10^6; // atoms/m^3
14 R_si = N_D/A_D; // ratio
15 disp(R_si, "The ratio of donor atom to silicon atom
    is");

```

Scilab code Exa 3.11 Equilibrium electron and hole densities

```

1 // Exa 3.11
2 format('v',9)
3 clc;
4 clear;

```



```

5 close;
6 // Given data
7 n_i = 1.5 * 10^10; // in per cm^3
8 n_n = 2.25 * 10^15; // in per cm^3
9 p_n = (n_i)^2/n_n; // in per cm^3
10 disp(p_n,"The equilibrium electron per cm^3 is");
11 h_n = n_n; // in cm^3
12 disp(h_n,"Hole densities in per cm^3 is");

```

Scilab code Exa 3.12 Carrier concentration

```

1 // Exa 3.12
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 N_A = 2 * 10^16; // in atoms/cm^3
8 N_D = 10^16; // in atoms/cm^3
9 C_c = N_A - N_D; // C_c stands for Carrier
   concentration in /cm^3
10 disp(C_c,"Carrier concentration per cm^3 is");

```

Scilab code Exa 3.13 Generation rate due to irradiation

```

1 // Exa 3.13
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 del_n = 10^15; // in cm^3
8 Torque_p = 10 * 10^-6; // in sec

```

```

9 R_g = del_n/Torque_p;// in hole pairs/sec/cm^3
10 disp(R_g,"The rate of generation of minority carrier
    in electron hole pairs/sec/cm^3 is ");

```

Scilab code Exa 3.14 Mobility of minority charge carrier

```

1 // Exa 3.14
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 v = 1/(20 * 10^-6);// in cm/sec
8 E = 10;// in V/cm
9 Mu= v/E;// in cm^2/V-sec
10 disp(Mu,"The mobility of minority charge carrier in
    cm^2/V-sec is ");

```

Scilab code Exa 3.15 Hall and electron diffusion current

```

1 // Exa 3.15
2 format('v',8)
3 clc;
4 clear;
5 close;
6 // Given data
7 q = 1.6 * 10^-19;// in C
8 N_D = 4.5 * 10^15;// in /cm^3
9 del_p = 10^21;
10 e=10;// in cm
11 A = 1;// in mm^2
12 A = A * 10^-14;// cm^2
13 l = 10;// in cm

```

```

14 Torque_p = 1; // in microsec
15 Torque_p = Torque_p * 10^-6; // in sec
16 Torque_n = 1; // in microsec
17 Torque_n = Torque_n * 10^-6; // in sec
18 n_i = 1.5 * 10^10; // in /cm^3
19 D_n = 30; // in cm^2/sec
20 D_p = 12; // in cm^2/sec
21 n_o = N_D; // in /cm^3
22 p_o = (n_i)^2/n_o; // in /cm^3
23 disp(p_o,"Hole concentration at thermal equilibrium
    per cm^3 is");
24 l_n = sqrt(D_n * Torque_n); // in cm
25 disp(l_n,"Diffusion length of electron in cm is");
26 l_p = sqrt(D_p * Torque_p); // in cm
27 disp(l_p,"Diffusion length of holes in cm is");
28 x=34.6*10^-4; // in cm
29 dpBYdx = del_p * e; // in cm^4
30 disp(dpBYdx,"Concentration gradient of holes at
    distance in cm^4 is");
31 e1 = 1.88 * 10^1; // in cm
32 dnBYdx = del_p * e1; // in cm^4
33 disp(dnBYdx,"Concentration gradient of electrons in
    per cm^4 is");
34 J_P = -(q) * D_p * dpBYdx; // in A/cm^2
35 disp(J_P,"Current density of holes due to diffusion
    in A/cm^2 is");
36 J_n = q * D_n * dnBYdx; // in A/cm^2
37 disp(J_n,"Current density of electrons due to
    diffusion in A/cm^2 is");

```

Scilab code Exa 3.16 Energy band gap of semiconductor material used

```

1 // Exa 3.16
2 format('v',5)
3 clc;

```

```

4 clear;
5 close;
6 // Given data
7 e= 1.6*10^-19; // electron charge in C
8 h = 6.626 * 10^-34; // in J-s
9 h= h/e; // in eV
10 c = 3 * 10^8; // in m/s
11 lambda = 5490 * 10^-10; // in m
12 f = c/lambda;
13 E = h * f; // in eV
14 disp(E,"The energy band gap of the semiconductor
      material in eV is");

```

Scilab code Exa 3.17 Current density in Si

```

1 // Exa 3.17
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 y2 = 6 * 10^16; // in /cm^3
8 y1 = 10^17; // in /cm^3
9 x2 = 2; // in m
10 x1 = 0; // in m
11 D_n = 35; // in cm^2/sec
12 q = 1.6 * 10^-19; // in C
13 dnBYdx = (y2 - y1)/((x2-x1) * 10^-4);
14 J_n = q * D_n * dnBYdx; // in A/cm^2
15 disp(J_n,"The current density in silicon in A/cm^2
      is");

```

Scilab code Exa 3.18 Resistance of the bar

```

1 // Exa 3.18
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 q = 1.6 * 10^-19; // in C
8 n_n = 5 * 10^20; // in /m^3
9 n_n = n_n * 10^-6; // in cm^3
10 Mu_n = 0.13; // in m^2/V-sec
11 Mu_n = Mu_n * 10^4; // in cm^2/V-sec
12 Sigma_n = q * n_n * Mu_n; // in (ohm-cm)^-1
13 Rho = 1/Sigma_n; // in -cm
14 l = 0.1; // in cm
15 A = 100; // m^2
16 A = A * 10^-8; // in cm^2
17 R = Rho * (l/A); // in Ohm
18 R=round(R*10^-6); // in M
19 disp(R,"The resistance of the bar in M is");

```

Scilab code Exa 3.19 Depletion width

```

1 // Exa 3.19
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 t_d = 3; // total depletion in m
8 // The depletion width ,
9 D = t_d/9; // in m
10 disp(D,"Depletion width in m is");

```

Scilab code Exa 3.20 Minority carrier density

```
1 // Exa 3.20
2 format('v',8)
3 clc;
4 clear;
5 close;
6 // Given data
7 n_i = 1.5 * 10^16; // in /m^3
8 n_n = 5 * 10^20; // in /m^3
9 p_n = (n_i)^2/n_n; // in /m^3
10 disp(p_n,"The majority carrier density per m^3 is");
```

Scilab code Exa 3.21 Collector current density

```
1 // Exa 3.21
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 D_n = 25; // in cm^2/sec
8 q = 1.6 * 10^-19; // in C
9 y2 = 10^14; // in /cm^3
10 y1 = 0; // in /cm^3
11 x2 = 0; // in m
12 x1 = 0.5; // in m
13 x1 = x1 * 10^-4; // in cm
14 dnBYdx = abs((y2-y1)/(x2-x1)); // in /cm^4
15 // The collector current density
16 J_n = q * D_n * (dnBYdx); // in /cm^4
17 J_n = J_n * 10^-1; // in A/cm^2
18 disp(J_n,"The collector current density in A/cm^2 is
19 ");
```

20 // Note: In the book, the calculated value of dn by
dx (2×10^{19}) is wrong. Correct value is 2×10^{18}
so the answer in the book is wrong.

Scilab code Exa 3.22 Band gap

```
1 //Exa 3.22
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 h = 6.64 * 10^-34; // in J-s
8 e= 1.6*10^-19; // electron charge in C
9 c= 3 * 10^8; // in m/s
10 lambda = 0.87; // in m
11 lambda = lambda * 10^-6; // in m
12 E_g = (h * c)/lambda; // in J-s
13 E_g= E_g/e; // in eV
14 disp(E_g,"The band gap of the material in eV is");
```

Scilab code Exa 3.23 Total energy absorbed by sample

```
1 // Exa 3.23
2 format('v',8)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_o = 10; // in mW
8 e = 1.6 * 10^-19; // in J/eV
9 hv = 2; // in eV
10 hv1=1.43; // in eV
```

```

11 alpha = 5 * 10^4; // in cm^-1
12 l = 46; // in m
13 l = 1 * 10^-6; // in m
14 I_t = round(I_o * exp(-(alpha) * l)); // in mW
15 AbsorbedPower= I_o-I_t; // in mW
16 AbsorbedPower=AbsorbedPower*10^-3; // in W or J/s
17 disp(AbsorbedPower,"The absorbed power in watt or J/
    s is");
18 F= (hv-hv1)/hv; // fraction of each photon energy
    unit
19 EnergyConToHeat= AbsorbedPower*F; // in J/s
20 disp(EnergyConToHeat,"The amount of energy converted
    to heat per second in J/s is : ")
21 A= (AbsorbedPower-EnergyConToHeat)/(e*hv1);
22 disp(A,"The number of photon per sec given off from
    recombination events in photons/s is");

```

Scilab code Exa 3.24 Hole current

```

1 // Exa 3.24
2 format('v',9)
3 clc;
4 clear;
5 close;
6 // Given data
7 Mu_p = 500; // in cm^2/V-sec
8 kT = 0.0259;
9 Toh_p = 10^-10; // in sec
10 p_o = 10^17; // in cm^-3
11 q= 1.6*10^-19; // in C
12 A=0.5; // in square meter
13 del_p = 5 * 10^16; // in cm^-3
14 n_i= 1.5*10^10; // in cm^-3
15 D_p = kT * Mu_p; // in cm/s
16 L_p = sqrt(D_p * Toh_p); // in cm

```



```
17 x = 10^-5; // in cm
18 p = p_o+del_p* %e^(x/L_p); // in cm^-3
19 // p= n_i*%e^(Eip)/kT where Eip=E_i-F_p
20 Eip= log(p/n_i)*kT; // in eV
21 Ecp= 1.1/2-Eip; // value of E_c-E_p in eV
22 Ip= q*A*D_p/L_p*del_p/%e^(x/L_p); // in A
23 disp(Ip,"The hole current in A is : ")
24 Qp= q*A*del_p*L_p; // in C
25 disp(Qp,"The value of Qp in C is : ")
```

Chapter 4

Junctions

Scilab code Exa 4.2 Tuning range

```
1 // Exa 4.2
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 C1= 5*10^-12; // in F
8 C2= 5*10^-12; // in F
9 L= 10*10^-3; // in H
10 C_Tmin= C1*C2/(C1+C2); // in F
11 f_omax= 1/(2*pi*sqrt(L*C_Tmin)); // in Hz
12 C1= 50*10^-12; // in F
13 C2= 50*10^-12; // in F
14 C_Tmax= C1*C2/(C1+C2); // in F
15 f_omin= 1/(2*pi*sqrt(L*C_Tmax)); // in Hz
16 f_omax= f_omax*10^-6; // in MHz
17 f_omin= f_omin*10^-3; // in kHz
18 disp(f_omax,"The maximum value of resonant frequency
    in MHz is : ")
19 disp(f_omin,"The minimum value of resonant frequency
    in kHz is : ")
```

Scilab code Exa 4.3 Contact difference of potential

```
1 // Exa 4.3
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 t = 4.4 * 10^22; // total number of Ge atoms/cm^3
8 n = 1 * 10^8; // number of impurity atoms
9 N_A = t/n; // in atoms/cm^3
10 N_A = N_A * 10^6; // in atoms/m^3
11 N_D = N_A * 10^3; // in atoms/m^3
12 n_i = 2.5 * 10^13; // in atoms/cm^3
13 n_i = n_i * 10^6; // in atoms/m^3
14 V_T = 26; // in mV
15 V_T = V_T * 10^-3; // in V
16 // The contact potential for Ge semiconductor,
17 V_J = V_T * log((N_A * N_D)/(n_i)^2); // in V
18 disp(V_J, "The contact potential for Ge semiconductor
    in V is");
19 // Part (b)
20 t = 5 * 10^22; // total number of Si atoms/cm^3
21 N_A = t/n; // in atoms/cm^3
22 N_A = N_A * 10^6; // in atoms/m^3
23 N_D = N_A * 10^3; // in atoms/m^3
24 n_i = 1.5 * 10^10; // in atoms/cm^3
25 n_i = n_i * 10^6; // in atoms/m^3
26 V_T = 26; // in mV
27 V_T = V_T * 10^-3; // in V
28 // The contact potential for Si P-N junction,
29 V_J = V_T * log((N_A * N_D)/(n_i)^2); // in V
30 disp(V_J, "The contact potential for Si P-N junction
    in V is");
```

Scilab code Exa 4.4 Height of the potential energy barrier

```
1 // Exa 4.4
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_T = 26; // in mV
8 V_T=V_T*10^-3; // in V
9 n_i = 2.5 * 10^13;
10 Sigma_p = 1;
11 Sigma_n = 1;
12 Mu_n = 3800;
13 q = 1.6 * 10^-19; // in C
14 Mu_p = 1800;
15 N_A = Sigma_p/(2* q * Mu_p); // in /cm^3
16 N_D = Sigma_n / (q * Mu_n); // in /cm^3
17 // The height of the energy barrier for Ge,
18 V_J = V_T * log((N_A * N_D)/(n_i)^2); // in V
19 disp(V_J,"For Ge the height of the energy barrier in
    V is");
20 // For Si p-n junction
21 n_i = 1.5 * 10^10;
22 Mu_n = 1300;
23 Mu_p = 500;
24 N_A = Sigma_p/(2* q * Mu_p); // in /cm^3
25 N_D = Sigma_n / (q * Mu_n); // in /cm^3
26 // The height of the energy barrier for Si p-n
    junction ,
27 V_J = V_T * log((N_A * N_D)/(n_i)^2); // in V
28 disp(V_J,"For Si p-n junction the height of the
    energy barrier in V is");
```

Scilab code Exa 4.5 Forward current

```
1 //Exa 4.5
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 Eta = 1;
8 V_T = 26; // in mV
9 V_T= V_T*10^-3; // in V
10 //From equation of the diode current,  $I = I_o * (\%e^{(V/(Eta*V_T))} - 1)$  and  $I = -(0.9) * I_o$ 
11 V= log(1-0.9)*V_T; //voltage in V
12 disp(V,"The voltage in volts is : ")
13 // Part (ii)
14 V1=0.05; // in V
15 V2= -0.05; // in V
16 // The ratio of the current for a forward bias to
    reverse bias
17 ratio= (%e^(V1/(Eta*V_T))-1)/(%e^(V2/(Eta*V_T))-1)
18 disp(ratio,"The ratio of the current for a forward
    bias to reverse bias is : ")
19 // Part (iii)
20 Io= 10; // in A
21 Io=Io*10^-3; // in mA
22 //For
23 V=0.1; // in V
24 // Diode current
25 I = Io * (%e^(V/(Eta*V_T)) - 1); // in mA
26 disp(I,"For V=0.1 V , the value of I in mA is : ")
27 //For
28 V=0.2; // in V
29 // Diode current
```

```

30 I = Io * (%e^(V/(Eta*V_T)) - 1); // in mA
31 disp(I,"For V=0.2 V , the value of I in mA is : ")
32 //For
33 V=0.3; // in V
34 // Diode current
35 I = Io * (%e^(V/(Eta*V_T)) - 1); // in mA
36 disp(I*10^-3,"For V=0.3 V , the value of I in A is :
      ")
37 disp("From three value of I, for small rise in
      forward voltage , the diode current increase
      rapidly")

```

Scilab code Exa 4.6 Anticipated factor

```

1 //Exa 4.6
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 // Part (i)
8 T1= 25; // in C
9 T2= 80; // in C
10 // Formula Io2= Io1*2^((T2-T1)/10)
11 AntiFactor= 2^((T2-T1)/10);
12 disp(round(AntiFactor),"Anticipated factor for Ge is
      : ")
13 // Part (ii)
14 T1= 25; // in C
15 T2= 150; // in C
16 AntiFactor= 2^((T2-T1)/10);
17 disp(round(AntiFactor),"Anticipated factor for Si is
      : ")

```

Scilab code Exa 4.7 Leakage resistance

```
1 //Exa 4.7
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I=5; // in A
8 V=10; // in V
9 T1= 0.11; // in C^-1
10 T2= 0.07; // in C^-1
11 // Io+IR=I (i)
12 // dIo/dT = dIo_by_dT (ii)
13 // 1/Io*dIo_by_dT = T1 and 1/I*dIo_by_dT = T2, So
14 Io= T2*I/T1; // in A
15 IR= I-Io; // in A
16 R= V/IR; // in M
17 disp(R,"The leakage resistance in M is : ")
```

Scilab code Exa 4.8 Dynamic resistance

```
1 //Exa 4.8
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 Eta = 1;
8 T = 125; // in C
9 T = T + 273; // in K
10 VT = 8.62 * 10^-5 * 398; // in V
```

```

11 I_o = 30; // in A
12 I_o= I_o*10^-6; // in A
13 v = 0.2; // in V
14 // The dynamic resistance in the forward direction
15 r_f = (Eta * V_T)/(I_o * %e^(v/(Eta* V_T))); // in
    ohm
16 disp(r_f,"The dynamic resistance in the forward
    direction in ohm is ");
17 // The dynamic resistance in the reverse direction
18 r_r = (Eta * V_T)/(I_o * %e^(-v/(Eta* V_T))); // in
    ohm
19 r_r= r_r*10^-3; // in k ohm
20 disp(r_r,"The dynamic resistance in the reverse
    direction in kohm is");

```

Scilab code Exa 4.9 Barrier capacitance

```

1 // Exa 4.9
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 epsilon = 16/(36 * %pi * 10^11); // in F/cm
8 A = 1 * 10^-2;
9 W = 2 * 10^-4;
10 // The barrier capacitance
11 C_T = (epsilon * A)/W; // in F
12 C_T= C_T*10^12; // in pF
13 disp(C_T,"The barrier capacitance in pF is");

```

Scilab code Exa 4.10 Width of the depletion layer


```

1 //Exa 4.10
2 format('v',6)
3 clc;
4 clear;
5 close;
6 //Given data
7 A = 1; // in mm^2
8 A = A * 10^-6; // in m^2
9 N_A = 3 * 10^20; // in atoms/m^3
10 q = 1.6 * 10^-19; // in C
11 V_o = 0.2; // in V
12 epsilon_r=16;
13 epsilon_o= 8.854*10^-12; // in F/m
14 epsilon=epsilon_r*epsilon_o;
15 // Part (a)
16 V=-10; // in V
17 // V_o - V = 1/2*((q * N_A )/epsilon) * W^2
18 W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A)); // m
19 W= W*10^6; // in m
20 disp(W,"The width of the depletion layer for an
    applied reverse voltage of 10V in m is ");
21 W= W*10^-6; // in m
22 C_T1 = (epsilon * A)/W; // in F
23 C_T1= C_T1*10^12; // in pF
24 // Part (b)
25 V=-0.1; // in V
26 W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A)); // m
27 W= W*10^6; // in m
28 disp(W,"The width of the depletion layer for an
    applied reverse voltage of 0.1V in m is ");
29 W= W*10^-6; // in m
30 C_T2 = (epsilon * A)/W; // in F
31 C_T2= C_T2*10^12; // in pF
32 // Part (c)
33 V=0.1; // in V
34 W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A)); // m
35 W= W*10^6; // in m
36 disp(W,"The width of the depletion layer for an

```

```

    applied for a forward bias of 0.1V in m is ");
37 // Part (d)
38 disp(C_T1,"The space charge capacitance for an
    applied reverse voltage of 10V in pF is");
39 disp(C_T2,"The space charge capacitance for an
    applied reverse voltage of 0.1V in pF is");

```

Scilab code Exa 4.11 Current in the junction

```

1 // Exa 4.11
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_o = 1.8 * 10^-9; // A
8 v = 0.6; // in V
9 Eta = 2;
10 V_T = 26; // in mV
11 V_T=V_T*10^-3; // in V
12 // The current in the junction
13 I = I_o * (%e^(v/(Eta * V_T))); // in A
14 I= I*10^3; // in mA
15 disp(I,"The current in the junction in mA is");

```

Scilab code Exa 4.12 Forward biasing voltage

```

1 // Exa 4.12
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data

```

```

7 I_o = 2.4 * 10^-14;
8 I = 1.5; // in mA
9 I=I*10^-3; // in A
10 Eta = 1;
11 V_T = 26; // in mV
12 V_T= V_T*10^-3; // in V
13 // The forward biasing voltage across the junction
14 v =log((I + I_o)/I_o) * V_T; // in V
15 disp(v,"The forward biasing voltage across the
    junction in V is");

```

Scilab code Exa 4.13 Theoretical diode current

```

1 // Exa 4.13
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_o = 10; // in nA
8 // I = I_o * ((e^(v/(Eta * V_T))) - 1) as diode is
    reverse biased by large voltage
9 // e^(v/(Eta * V_T)) << 1, so neglecting it
10 I = I_o * (-1); // in nA
11 disp(I,"The Diode current in nA is ");

```

Scilab code Exa 4.14 Diode dynamic resistance

```

1 // Exa 4.14
2 format('v',6)
3 clc;
4 clear;
5 close;

```

```

6 // Given data
7 R = 4.5; // in ohm
8 I = 44.4; // in mA
9 I=I*10^-3; // in A
10 V = R * I; // in V
11 Eta = 1;
12 V_T = 26; // in mV
13 V_T=V_T*10^-3; // in V
14 // Reverse saturation current ,
15 I_o = I/((%e^(V/(Eta * V_T))) -1); // in A
16 // Dynamic resistance at 0.1 V forward bias
17 V = 0.1; // in V
18 // The diode dynamic resistance ,
19 r_f = (Eta * V_T)/(I_o * ((%e^(V/(Eta * V_T))) -1));
    // in ohm
20 disp(r_f,"The diode dynamic resistance in is");

```

Scilab code Exa 4.15 DC load line and operating point

```

1 // Exa 4.15
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_D = 10; // in V
8 // V_S = i*R_L + V_D
9 V_S = V_D; // in V (i * R_L = 0)
10 disp(V_S,"when diode is OFF, the voltage in volts is
    : ");
11 R_L = 250; // in ohm
12 I = V_S/R_L; // in A
13 disp(I*10^3,"when diode is ON, the current in mA is"
    );
14 V_D= 0:0.1:10; // in V

```

```

15 I= (V_S-V_D)/R_L*1000; // in mA
16 plot(V_D,I)
17 xlabel("V_D in volts");
18 ylabel("Current in mA")
19 title("DC load line");
20 disp("DC load line shown in figure")

```

Scilab code Exa 4.16 AC resistance of a Ge diode

```

1 // Exa 4.16
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V = 0.25; // in V
8 I_o = 1.2; // in A
9 I_o = I_o * 10^-6; // in A
10 V_T = 26; // in mV
11 V_T = V_T * 10^-3; // in V
12 Eta = 1;
13 // The ac resistance of the diode
14 r = (Eta * V_T)/(I_o * (%e^(V/(Eta * V_T)))); // in
    ohm
15 disp(r,"The ac resistance of the diode in ohm is");

```

Scilab code Exa 4.17 Junction potential

```

1 // Exa 4.17
2 format('v',6)
3 clc;
4 clear;
5 close;

```

```

6 // Given data
7 t = 4.4 * 10^22; // in total number of atoms/cm^3
8 n = 1 * 10^8; // number of impurity
9 N_A = t/n; // in atoms/cm^3
10 N_A = N_A * 10^6; // in atoms/m^3
11 N_D = N_A * 10^3; // in atoms/m^3
12 V_T = 26; // in mV
13 V_T = V_T * 10^-3; // in V
14 n_i = 2.5 * 10^19; // in /cm^3
15 // The junction potential
16 V_J = V_T * log((N_A * N_D)/(n_i)^2); // in V
17 disp(V_J,"The junction potential in V is")

```

Scilab code Exa 4.18 Dynamic resistance

```

1 // Exa 4.18
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 Eta = 1;
8 I_o = 30; // in MuA
9 I_o = I_o * 10^-6; // in A
10 v = 0.2; // in V
11 K = 1.381 * 10^-23; // in J/degree K
12 T = 125; // in C
13 T = T + 273; // in K
14 q = 1.6 * 10^-19; // in C
15 V_T = (K*T)/q; // in V
16 // The forward dynamic resistance ,
17 r_f = (Eta * V_T)/(I_o * (%e^(v/(Eta * V_T)))); // in
    ohm
18 disp(r_f,"The forward dynamic resistance in ohm is")
    ;

```

```

19 // The Reverse dynamic resistance
20 r_f1 = (Eta * V_T)/(I_o * (%e^(-(v)/(Eta * V_T))));
    // in ohm
21 r_f1= r_f1*10^-3;// in k ohm
22 disp(r_f1,"The Reverse dynamic resistance in k is"
    );

```

Scilab code Exa 4.19 Width of the depletion layer

```

1 // Exa 4.19
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 q = 1.6 * 10^-19;// in C
8 N_A = 3 * 10^20;// in /m^3
9 A = 1;// in m^2
10 A = A * 10^-6;// in m^2
11 V = -10;// in V
12 V_J = 0.25;// in V
13 V_B = V_J - V;// in V
14 epsilon_o = 8.854;// in pF/m
15 epsilon_o = epsilon_o * 10^-12;// in F/m
16 epsilon_r = 16;
17 epsilon = epsilon_o * epsilon_r;
18 // The width of depletion layer ,
19 W = sqrt((V_B * 2 * epsilon)/(q * N_A));// in m
20 W=W*10^6;// in m
21 disp(W,"The width of depletion layer in m is");
22 W=W*10^-6;// in m
23 // The space charge capacitance ,
24 C_T = (epsilon * A)/W;// in pF
25 C_T=C_T*10^12;// in pF
26 disp(C_T,"The space charge capacitance in pF is");

```

Scilab code Exa 4.20 Barrier capacitance of a Ge pn junction

```
1 // Exa 4.20
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 W = 2 * 10^-4; // in cm
8 W = W * 10^-2; // in m
9 A = 1; // in mm^2
10 A = A * 10^-6; // in m^2
11 epsilon_r = 16;
12 epsilon_o = 8.854 * 10^-12; // in F/m
13 epsilon = epsilon_r * epsilon_o;
14 C_T = (epsilon * A)/W; // in F
15 C_T = C_T * 10^12; // in pF
16 disp(C_T, "The barrier capacitance in pF is");
```

Scilab code Exa 4.21 Diameter

```
1 // Exa 4.21
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 C_T = 100; // in pF
8 C_T = C_T * 10^-12; // in F
9 epsilon_r = 12;
10 epsilon_o = 8.854 * 10^-12; // in F/m
```



```

11 epsilon = epsilon_r * epsilon_o;
12 Rho_p = 5; // in ohm-cm
13 Rho_p = Rho_p * 10^-2; // in ohm-m
14 V_j = 0.5; // in V
15 V = -4.5; // in V
16 Mu_p = 500; // in cm^2
17 Mu_p = Mu_p * 10^-4; // in m^2
18 Sigma_p = 1/Rho_p; // in per ohm-m
19 qN_A = Sigma_p/ Mu_p;
20 V_B = V_j - V;
21 W = sqrt((V_B * 2 * epsilon)/qN_A); // in m
22 //C_T = (epsilon * A)/W;
23 A = (C_T * W)/ epsilon; // in m
24 D = sqrt(A * (4/%pi)); // in m
25 D = D * 10^3; // in mm
26 disp(D,"The diameter in mm is");

```

Scilab code Exa 4.22 Temperature of junction

```

1 // Exa 4.22
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 q = 1.6 * 10^-19; // in C
8 Mu_p = 500; // in cm^2/V-sec
9 Rho_p = 3.5; // in ohm-cm
10 Mu_n = 1500; // in cm^2/V-sec
11 Rho_n = 10; // in ohm-cm
12 N_A = 1/(Rho_p * Mu_p * q); // in /cm^3
13 N_D = 1/(Rho_n * Mu_n * q); // in /cm^3
14 V_J = 0.56; // in V
15 n_i = 1.5 * 10^10; // in /cm^3
16 V_T = V_J/log((N_A * N_D)/(n_i)^2); // in V

```

```

17 // V_T = T/11600
18 T = V_T * 11600; // in K
19 T = T - 273; // in C
20 disp(T,"The Temperature of junction in C is");

```

Scilab code Exa 4.23 Voltage

```

1 // Exa 4.23
2 format('v',7)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_T = 26; // in mV
8 V_T = V_T * 10^-3; // in V
9 Eta = 1;
10 // I = -90% for I_o, so
11 IbyIo= 0.1;
12 // I = I_o * ((e^(v/(Eta * V_T)))-1)
13 V = log(IbyIo) * V_T; // in V
14 disp(V,"The reverse bias voltage in volts is");

```

Scilab code Exa 4.24 Reverse saturation current

```

1 // Exa 4.24
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 R = 5; // in ohm
8 I = 50; // in mA
9 I=I*10^-3; // in A

```

```

10 V = R * I; // in V
11 Eta = 1;
12 V_T = 26; // in mV
13 V_T=V_T*10^-3; // in V
14 // The reverse saturation current
15 I_o = I/((%e^(V/(Eta * V_T))) - 1); // in A
16 I_o= I_o*10^6; // in A
17 disp(I_o,"Reverse saturation current in A is");
18 I_o= I_o*10^-6; // in A
19 v1 = 0.2; // in V
20 // The dynamic resistance of the diode,
21 r = (Eta * V_T)/(I_o * (%e^(v1/(Eta * V_T)))); // in
    ohm
22 disp(r,"Dynamic resistance of the diode in is");

```

Chapter 5

MOSFETs

Scilab code Exa 5.1 Current

```
1 // Exa 5.1
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_TN = 0.7; // in V
8 W = 45*10^-4; // in cm
9 L = 4; // in m
10 L = L * 10^-4; // in cm
11 t_ox = 450; // in
12 t_ox = t_ox*10^-8; // in cm
13 V_GS = 1.4; // in V
14 Miu_n = 700; // in cm^2/V-s
15 Epsilon_ox = (8.85*10^-14)*(3.9); // in F/cm
16 // Conduction parameter can be expressed as,
17 k_n = (W*Miu_n*Epsilon_ox)/(2*L*t_ox); // A/V^2
18 k_n= k_n*10^3; // in mA/V^2
19 disp(k_n,"The value of k_n in mA/V^2 is : ")
20 k_n= k_n*10^-3; // in A/V^2
21 // The drain current ,
```

```

22 I_D = k_n*((V_GS-V_TN)^2); // in A
23 I_D= I_D*10^3; // in mA
24 disp(I_D,"The current in mA is ");
25
26 // Note: There is a calculation error to find the
    value of k_n, So the answer in the book is wrong

```

Scilab code Exa 5.2 IDQ and VDSQ

```

1 // Exa 5.2
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_Don = 6; // in mA
8 I_Don= I_Don*10^-3; // in A
9 V_GSon = 8; // in V
10 V_GSth = 3; // in V
11 V_DD = 12; // in V
12 R_D= 2*10^3; // in
13 k= I_Don/(V_GSon-V_GSth)^2; // in A/V^2
14 // I_D= k*[V_GS-V_GSth]^2 but V_GS= V_DD-I_D*R_D, So
15 // I_D= k*(V_DD-I_D*R_D-V_GSth)^2 or
16 // I_D^2*R_D^2+I_D*(2*R_D*V_GSth-2*R_D*V_DD-1/k)+(
    V_DD-V_GSth)^2
17 A= R_D^2; // assumed
18 B= 2*R_D*V_GSth-2*R_D*V_DD-1/k; // assumed
19 C= (V_DD-V_GSth)^2; // assumed
20 // Evaluating the value of I_D
21 root= [A B C];
22 root= roots(root); // in A
23 disp("The value of I_D is : "+string(root(1)*10^3)+"
    mA or "+string(root(2)*10^3)+" mA")
24 I_DQ= root(2); // in A

```

```
25 disp(I_DQ*10^3,"The value of I_DQ in mA is : ")
26 V_DSQ= V_DD-I_DQ*R_D;// in V
27 disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 5.3 Designing of biasing circuit

```
1 // Exa 5.3
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_GS = 6;// in V
8 I_D = 4;// in mA
9 V_GSth = 2;// in V
10 V_DS = V_GS;// in V
11 // For a good design
12 V_DD = 2*V_DS;// in V
13 disp(V_DD,"The value of V_DD in V is")
14 R_D = (V_DD-V_DS)/I_D;// in k ohm
15 disp(R_D,"The value of R_D in k ohm is ");
16 disp("The very high value for the gate to drain
    resistance is : 10 M ")
```

Scilab code Exa 5.4 IDQ VGSQ and VDS

```
1 // Exa 5.4
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_Don = 3*10^-3;
```

```

8 V_GSon = 10; // in V
9 V_GSth= 5; // in V
10 R2= 18*10^6; // in
11 R1= 22*10^6; // in
12 R_S=820; // in
13 R_D=3*10^3; // in
14 V_DD= 40; // in V
15 V_G= V_DD*R2/(R1+R2); // in V
16 k= I_Don/(V_GSon-V_GSth)^2; // in A/V^2
17 // V_G= V_GS+V_RS= V_GS+I_D*R_S or V_GS= V_G-I_D*R_S
18 // I_D= k*[V_GS-V_GSth]^2 or
19 // I_D= k*(V_G-I_D*R_D-V_GSth)^2 or
20 // I_D^2*R_D^2+I_D*(2*R_D*V_GSth-2*R_D*V_DD-1/k)+(
    V_DD-V_GSth)^2
21 A= R_S^2; // assumed
22 B= 2*R_S*V_GSth-2*R_S*V_G-1/k; // assumed
23 C= (V_G-V_GSth)^2; // assumed
24 // Evaluating the value of I_D
25 I_D= [A B C]
26 I_D= roots(I_D); // in A
27 I_D= I_D(2); // in A
28 I_DQ= I_D; // in A
29 I_DQ= I_DQ*10^3; // in mA
30 disp(I_DQ,"The value of I_DQ in mA is : ")
31 I_DQ= I_DQ*10^-3; // in A
32 V_GSQ= V_G-I_DQ*R_S; // in V
33 disp(V_GSQ,"The value of V_GSQ in volts is : ")
34 V_DSQ= V_DD-I_DQ*(R_D+R_S); // in V
35 disp(V_DSQ,"The value of V_DSQ in volts is : ")

```

Scilab code Exa 5.5 IDSQ VGSQ and VDSQ

```

1 // Exa 5.5
2 format('v',6)
3 clc;

```

```

4 clear;
5 close;
6 // Given data
7 I_D= '0.3*(V_GS-V_P)^2';// given expression
8 V_DD= 30;// in V
9 V_P= 4;// in V
10 R_GS = 1.2*10^6;// in
11 R_G = 1.2*10^6;// in
12 Req= R_GS/(R_GS+R_G);// in
13 R_D= 15;// in
14 // V_DS= V_DD-I_D*R_D (applying KVL to drain circuit
    )
15 // V_GS= Req*V_DS= (V_DD-I_D*R_D)*Req
16 // from given expression
17 //I_D^2*(R_D*Req)^2 - I_D*(2*R_D*Req*(V_DD*Req-V_P)
    +1/0.3 + (V_DD*Req-V_P)^2)
18 A= (R_D*Req)^2;// assumed
19 B= -(2*R_D*Req*(V_DD*Req-V_P)+1/0.3);// assumed
20 C= (V_DD*Req-V_P)^2;// assumed
21 // Evaluating the value of I_D
22 I_D= [A B C]
23 I_D= roots(I_D);// in mA
24 I_D= I_D(2);// in mA
25 I_DSQ= I_D;// in mA
26 disp(I_DSQ,"The value of I_DSQ in mA is : ")
27 V_GS= (V_DD-I_D*R_D);// in V
28 disp(V_GS,"The value of V_GS in volts is : ")
29 V_DS= Req*V_GS;// in V
30 disp(V_DS,"The value of V_DS in volts is : ")

```

Scilab code Exa 5.6 ID and VDS and region of operation

```

1 // Exa 5.6
2 format('v',6)
3 clc;

```



```

4 clear;
5 close;
6 // Given data
7 k = 0.1; // in mA/V^2
8 V_T = 1; // in V
9 R1 = 33; // in k ohm
10 R2 = 21; // in k ohm
11 V_DD = 6; // in V
12 R_D = 18; // in k ohm
13 V_G = (R2/(R2+R1))*V_DD; // in V
14 V_S = 0; // in V
15 V_GS = V_G - V_S; // in V
16 I_D = k*((V_GS - V_T)^2); // in mA
17 disp(I_D, "The value of I_D in mA is");
18 V_DS = V_DD - (I_D*R_D); // in V
19 disp(V_DS, "The value of V_DS in V is");
20 V_DSsat = V_GS - V_T; // in V
21 disp(V_DSsat, "The value of V_DS(sat) in V is");
22 if V_DS > V_DSsat then
23     disp("MOSFET is in saturation region")
24 end

```

Scilab code Exa 5.7 DC load line and operating point

```

1 // Exa 5.7
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_DD = 6; // in V
8 R_D = 18; // in kohm
9 // for maximum value of I_D
10 V_DS = 0; // in V
11 I_Dmax = (V_DD - V_DS)/R_D; // in mA

```

```

12 // for maximum value of V_DS
13 I_D=0; // in mA
14 V_DSmax=V_DD-I_D*R_D; // in V
15 V_DS= 0:0.1:V_DSmax; // in V
16 I_D= (V_DD-V_DS)/R_D; // in mA
17 plot(V_DS,I_D)
18 xlabel("V_DS in volts")
19 ylabel("I_D in mA")
20 title("DC load line")
21 disp("DC load line shown in figure");
22 disp("Q-points are : 2.8V, 0.178 mA")

```

Scilab code Exa 5.8 Region at which MOSFET ia biased

```

1 // Exa 5.8
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 R2 = 18; // in k ohm
8 R1 = 33; // in k ohm
9 V_DD = 6; // in V
10 V_G = (R2/(R1+R2))*V_DD; // in V
11 V_S = V_DD; // in V
12 V_SG = V_S-V_G; // in V
13 disp(V_SG,"The value of V_SG in V is");
14 k = 0.1;
15 V_T = -1; // in V
16 I_D = k*((V_SG+V_T)^2); // in mA
17 disp(I_D,"The value of I_D in mA is");
18 R_D = 3; // in k ohm
19 V_SD = V_DD - (I_D*R_D); // in V
20 disp(V_SD,"The value of V_SD in V is");
21 V_SDsat = V_SG+V_T; // in V

```

```

22 disp(V_SDsat,"The value of V_SD(sat) in V is");
23 if V_SD>V_SDsat then
24     disp("The p MOSFET is indeed biased in the
           saturation region")
25 end

```

Scilab code Exa 5.9 IDQ and VDSQ

```

1 // Exa 5.9
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_G= 1.5; // in V
8 V_P= -3; // in V
9 R_S= 750; // in
10 R_D= 1800; // in
11 I_DSS= 6*10^-3; // in A
12 V_DD= 18; // in V
13 // V_GS= V_G-I_D*R_S
14 // I_D= I_DSS*(1-V_GS/V_P)^2 or I_DSS*(1-(V_G-I_D*
           R_S)/V_P)^2
15 // I_D^2*R_S^2+I_D*(2*R_S*(V_P-V_G)-V_P^2/I_DSS)+(V_P
           -V_G)^2
16 A= R_S^2;
17 B=(2*R_S*(V_P-V_G)-V_P^2/I_DSS);
18 C=(V_P-V_G)^2;
19 // Evaluating the value of I_D by using polynomial
20 I_D= [A B C]
21 I_D= roots(I_D); // in A
22 I_D= I_D(2); // in A
23 I_DQ= I_D; // in A
24 V_DS= V_DD-I_D*(R_D+R_S); // in V
25 V_DSQ= V_DS; // in V

```

```
26 disp(I_DQ*10^3,"The value of I_DQ in mA is : ")
27 disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 5.10 Necessary value of Rs

```
1 // Exa 5.10
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_GS = 4; // in V
8 V_P = 2; // in V
9 R2 = 10; // in k ohm
10 R1 = 30; // in k ohm
11 R_D= 2.5; // in kohm
12 I_D= 15; // in mA
13 I_D= I_D*10^-3; // in A
14 V_DD = 25; // in V
15 V_G = (V_DD/R_D)*V_DD/(R1+R2); // in V
16 // The necessary value for R_S
17 R_S = (V_G-V_GS)/I_D; // in ohm
18 disp(R_S,"The value of R_S in ohm is");
```

Scilab code Exa 5.11 ID and VDS

```
1 // Exa 5.11
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 k= 0.1; // in mA/V^2
```

```

8 V_T= 1; // in V
9 R2= 87*10^3; // in
10 R1= 110*10^3; // in
11 R_S=2; // in k
12 R_D=2; // in k
13 //R_D=3*10^3; // in
14 V_DD= 6; // in V
15 V_SS= 6; // in V
16 V_G= (V_DD+V_SS)*R2/(R1+R2); // in V
17 // V_S= I_D*R_S-V_SS
18 // V_GS= V_G-V_S= V_G+V_SS-(I_D*R_S)
19 // I_D= k*[V_GS-V_T]^2 = k*[(V_G+V_SS-V_T)-(I_D*R_S)]
    ]^2
20 // (I_D*R_S)^2- I_D*(2*R_S*(V_G+V_SS-V_T)+1/k) +(
    V_G+V_SS-V_T)^2
21 A= R_S^2; // assumed
22 B= -(2*R_S*(V_G+V_SS-V_T)+1/k); // assumed
23 C= (V_G+V_SS-V_T)^2; // assumed
24 I_D= [A B C]
25 I_D= roots(I_D); // in mA
26 I_D= I_D(2); // in mA
27 disp(I_D,"The value of I_D in mA is : ")
28 // Applying KVL to drain source loop, V_DD+V_SS= I_D
    *R_D+V_DS+I_D*R_S
29 V_DS=V_DD+V_SS-I_D*R_D-I_D*R_S; // in V
30 disp(V_DS,"The value of V_DS in volts is : ")

```

Scilab code Exa 5.12 Designing of NMOS CS circuit

```

1 // Exa 5.12
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data

```

```

7 k = 0.16; // in mA/V^2
8 V_T = 2; // in V
9 I_D = 0.5; // in mA
10 V_DD = 6; // in V
11 V_SS = -6; // in V
12 V_GS = V_T + (sqrt(I_D/k)); // in V
13 R_S = 2; // in k ohm
14 V_S = (I_D*R_S) - V_DD; // in V
15 V_G = V_GS+V_S; // in V
16 I = 0.1*I_D; // in mA
17 R2 = (V_G+V_DD)/I; // in k ohm
18 disp(R2,"The value of R2 in k ohm is");
19 R1 = (V_DD - V_G)/I; // in k ohm
20 disp(R1,"The value of R1 in k ohm is");
21 R_D = 10; // in k ohm
22 V_DS = (V_DD-V_SS) - (I_D*(R_S+R_D)); // in V
23 disp(V_DS,"The value of V_DS in V is");
24 V_DSsat = V_GS-V_T; // in V
25 disp(V_DSsat,"The value of V_DS(sat) in V is");
26 if V_DS>V_DSsat then
27     disp("The MOSFET is in saturation region")
28 end
29
30 // Note: The value of R1 is in k ohm but in the book
    it is wrong.

```

Scilab code Exa 5.13 IDQ and VDS

```

1 // Exa 5.13
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_DD = 6; // in V

```

```

8 V_D = 3; // in V
9 R_D = 10; // in k ohm
10 // The value of I_DQ can be find as ,
11 I_DQ = (V_DD-V_D)/R_D; // in mA
12 disp(I_DQ,"The value of I_DQ in mA is");
13 V_T = 0.8; // in V
14 k = 0.12; // in mA/V^2
15 // The value of Ground to Source voltage ,
16 V_GS = sqrt(I_DQ/k) + V_T; // in V
17 V_S = -V_GS; // in V
18 // The value of Drain to Source voltage ,
19 V_DS = V_D-V_S; // in V
20 disp(V_DS,"The value of V_DS in V is");

```

Scilab code Exa 5.14 The region of operation

```

1 // Exa 5.14
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_D = 0.3; // in mA
8 k = 0.12; // in mA/V^2
9 V_T = 1; // in V
10 V_GS = V_T + (sqrt(I_D/k)); // in V
11 V_S = -V_GS; // in V
12 V_DD = 6; // in V
13 V_D = 3; // in V
14 I_DQ = 0.3; // in mA
15 R_D = (V_DD-V_D)/I_DQ; // in k ohm
16 disp(R_D,"The value of R_D in k ohm is");
17 V_DS = V_D - V_S; // in V
18 disp(V_DS,"The value of V_DS in V is");
19 V_DSsat = V_GS - V_T; // in V

```

```

20 disp(V_DSsat,"The value of V_DS(sat) in V is");
21 if V_DS>V_DSsat then
22     disp("The MOSFET is in saturation region")
23 end

```

Scilab code Exa 5.15 VDS VGS and ID

```

1 // Exa 5.15
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 k= 0.05; // in mA/V^2
8 V_T= 1; // in V
9 V_DD= 6; // in V
10 R_S= 9.1; //in k
11 //V_GS= V_DD-I_D*R_S
12 //I_D= k*(V_DD-I_D*R_S)^2
13 //I_D^2*R_S^2-I_D*(2*V_DD*R_S+1/k)+V_DD^2
14 A= R_S^2; // assumed
15 B=-(2*V_DD*R_S+1/k); // assumed
16 C= V_DD^2; // assumed
17 I_D= [A B C];
18 I_D= roots(I_D); // in mA
19 I_D= I_D(2); // in mA
20 V_GS= V_DD-I_D*R_S; // in V
21 V_DS= V_GS; // in V
22 disp(I_D,"The value of I_D in mA is : ")
23 disp(V_GS,"The value of V_GS in volts is : ")
24 disp(V_DS,"The value of V_DS in volts is : ")

```

Scilab code Exa 5.16 All dc voltages


```

1 // Exa 5.16
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 k1= 0.01; // in mA/V^2
8 k2= 0.05; // in mA/V^2
9 V_DD= 5; // in V
10 V_T1=1; // in V
11 V_T2=1; // in V
12 // Analysis for Vi= 5V
13 Vi= 5; // in V
14 // I_D1= k1*(V_GS1-V_T1)^2 and I_D2= k2*(2*(V_GS2-
    V_T2)*V_DS2-V_DS2^2)
15 // But V_GS2= Vi, V_DS2= Vo, V_GS1= V_DS1= V_DD-Vo
16 // Vo^2*(k1+k2)-Vo*[2*k1*(V_DD-V_T1)+2*k2*(Vi-V_T2)]+
    k1*(V_DD-V_T1)^2
17 A=(k1+k2);
18 B=-[2*k1*(V_DD-V_T1)+2*k2*(Vi-V_T2)];
19 C=k1*(V_DD-V_T1)^2;
20 Vo= [A B C]
21 Vo= roots(Vo); // in V
22 Vo= Vo(2); // in V
23 V_GS2= Vi; // in V
24 V_DS2= Vo; // in V
25 V_GS1= V_DD-Vo; // in V
26 I_D1= k1*(V_GS1-V_T1)^2; // in mA
27 I_D2= I_D1; // in mA
28 disp("Part (i) For Vi = 5 V")
29 disp(Vo,"The output voltage in volts is : ")
30 disp(I_D1,"The value of I_D1 in mA is : ")
31 disp(I_D2,"The value of I_D2 in mA is : ")
32 // Analysis for Vi= 1.5V
33 Vi= 1.5; // in V
34 // I_D2= k2*(V_GS2-V_T2)^2 and I_D1= k1*(V_GS1-V_T1)
    ^2
35 // But V_GS2= Vi, V_DS2= Vo, V_GS1= V_DS1= V_DD-Vo

```

```

36 //k2*(Vi-V_T2)^2= k1*(V_DD-Vo-V_T1)^2 or
37 Vo= V_DD-V_T1-sqrt(k2/k1)*(Vi-V_T2); // in V
38 I_D2= k2*(Vi-V_T2)^2; //in mA
39 I_D1= I_D2; // in mA
40 disp("Part (ii) For Vi = 1.5 V")
41 disp(Vo,"The output voltage in volts is : ")
42 disp(I_D1,"The value of I_D1 in mA is : ")
43 disp(I_D2,"The value of I_D2 in mA is : ")

```

Scilab code Exa 5.17 ID and VDS

```

1 // Exa 5.17
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 k = 0.12; // in mA/V^2
8 V_T = -2.5; // in V
9 V_GS = 0;
10 I_D = k*((V_GS-V_T)^2); // in mA
11 disp(I_D,"The value of I_D in mA is");
12 V_DD = 6; // in V
13 R_S = 4.7; // in k ohm
14 V_DS = V_DD -(I_D*R_S); // in V
15 disp(V_DS,"The value of V_DS in V is ");
16 V_S = 0; // in V
17 V_DSsat = V_S - V_T; // in V
18 disp(V_DSsat,"The value of V_DS(sat) in V is");
19 if V_DS<V_DSsat then
20     disp("The device is in the non saturation region
21         ")
21 end

```

Scilab code Exa 5.18 Various voltage and current

```
1 // Exa 5.18
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 k4 = 0.125; // in mA/V^2
8 k3 = k4; // in mA/V^2
9 k2 = k4; // in mA/V^2
10 k1 = 0.25; // in mA/V^2
11 V_T1 = 0.8; // in V
12 V_T2 = V_T1; // in V
13 V_T3 = V_T1; // in V
14 V_T4 = V_T1; // in V
15 V_SS = -5; // in V
16 V_DD = 5; // in V
17 R_D = 10; // in k ohm
18 // Required formula,  $V_{GS3} = ((\sqrt{k4/k3}) * (-V_{SS} - V_{T4})) + V_{T3} / (1 + \sqrt{k4/k3})$ 
19 V_GS3 = ((sqrt(k4/k3) * (-V_SS - V_T4)) + V_T3) / (1 +
    sqrt(k4/k3)); // in V
20 // Calculation to evaluate the value of I_Q,
21 I_Q = k2 * ((V_GS3 - V_T2)^2); // in mA
22 I_D1 = I_Q; // in mA
23 // The value of V_GS1,
24 V_GS1 = V_T1 + (sqrt(I_D1/k1)); // in V
25 disp(V_GS1, "The value of V_GS1 in V is");
26 // The value of V_DS2,
27 V_DS2 = (-V_SS - V_GS1); // in V
28 disp(V_DS2, "The value of V_DS2 in V is");
29 // The value of V_DS1,
30 V_DS1 = V_DD - (I_Q * R_D) - (V_SS + V_DS2); // in V
```

```
31 disp(V_DS1,"The value of V_DS1 in V is");
```

Scilab code Exa 5.19 Q point

```
1 // Exa 5.19
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 R2 = 20; // in k ohm
8 R1 = 30; // in k ohm
9 R_D = 20; // in k ohm
10 R_D=R_D*10^3; // in ohm
11 V_DD = 5; // in V
12 V_G = (R2/(R1+R2))*V_DD; // in V
13 V_S = 0; // in V
14 V_GS = V_G; // in V
15 k = 100*10^-6; // in A/V^2
16 V_T = 1; // in V
17 // The value of I_DQ,
18 I_DQ = k*((V_GS-V_T)^2); // in A
19 I_DQ= I_DQ * 10^6; // in A
20 disp(I_DQ,"The value of I_DQ in A is");
21 I_DQ= I_DQ * 10^-6; // in A
22 // The value of V_DSQ,
23 V_DSQ = V_DD - (I_DQ*R_D); // in V
24 disp(V_DSQ,"The value of V_DSQ in V is");
```

Scilab code Exa 5.20 IDQ VGSQ and VD

```
1 // Exa 5.20
2 format('v',6)
```

```

3  clc;
4  clear;
5  close;
6  // Given data
7  V_P= -8; // in V
8  R_S= 2.4; // in k
9  //R_D= 1800; // in
10 I_DSS= 8; // in mA
11 V_DD= 20; // in V
12 R_D= 6.2; // in k
13 // V_GS= -I_D*R_S
14 // I_D= I_DSS*(1-V_GS/V_P)^2 or I_DSS*(1-(-I_D*R_S)/
    V_P)^2
15 //I_D^2*R_S^2+I_D*(2*R_S*(V_P-V_G)-V_P^2/I_DSS)+(V_P
    )^2
16 A= R_S^2
17 B=(2*R_S*(V_P)-V_P^2/I_DSS)
18 C=(V_P)^2
19 I_D= [A B C]
20 // Evaluation fo I_D using by polynomial method
21 I_D= roots(I_D); // in mA
22 I_D= I_D(2); // in mA
23 I_DQ= I_D; // in mA
24 disp(I_DQ,"The value of I_DQ in mA is : ")
25 // The value of V_GSQ
26 V_GSQ= -I_D*R_S; // in V
27 disp(V_GSQ,"The value of V_GSQ in volts ")
28 // The value of V_D,
29 V_D= V_DD-I_D*R_D; // in V
30 disp(V_D,"The value of V_D in volts is : ")

```

Scilab code Exa 5.21 ID VD VS and VG

```

1 // Exa 5.21
2 format('v',6)

```

```

3  clc;
4  clear;
5  close;
6  // Given data
7  k= 75*10^-3; //in mA/V^2
8  Vth= -0.8; // in V
9  R2 = 100; // in k ohm
10 R1 = 100; // in k ohm
11 R_S= 6; // in k
12 R_D= 3; // in k
13 V_SS = 10; // in V
14 V_G = (R2/(R1+R2))*V_SS; // in V
15 I_D= poly(0, 'I_D');
16 V_S= V_SS-I_D*R_S; // in V
17 V_GS= V_G-V_S; //in V
18 I_D= I_D-k*(V_GS-Vth)^2;
19 I_D= roots(I_D); // in mA
20 // For I_D(1), the V_DS will be positive , so
    discarding this
21 I_D= I_D(2); // in mA
22 V_DS= -V_SS+I_D*(R_D+R_S); // in V
23 V_D= I_D*R_D; // in V
24 V_S= I_D*R_S; // in V
25 disp(I_D,"The value of I_D in mA is : ")
26 disp(V_DS,"The value of V_DS in volts is : ")
27 disp(V_D,"The value of V_D in volts is : ")
28 disp(V_S,"The value of V_S in volts is : ")

```

Scilab code Exa 5.22 Value of RD

```

1  // Exa 5.22
2  format('v',6)
3  clc;
4  clear;
5  close;

```

```

6 // Given data
7 V_T = 1; // in V
8 k = 160*10^-6; // in A/V^2
9 I_DQ = 160*10^-6; // in A
10 V_GS = V_T + sqrt(I_DQ/k); // in V
11 V_DD = 5; // in V
12 V_DSQ = 3; // in V
13 R_D = (V_DD - V_DSQ)/(I_DQ); // in ohm
14 R_D = R_D * 10^-3; // in k ohm
15 disp(R_D, "The value of R_D in k ohm is");

```

Scilab code Exa 5.23 Q point

```

1 // Exa 5.23
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_DD= 12; // in V
8 V_T= 2; // in V
9 kn= 0.5; // in mA/V^2
10 R1 = 2.2; // in M ohm
11 R2 = 1.8; // in M ohm
12 R_S= 1.5; // in k
13 R_D= 3.9; // in k
14 V_G = (R2/(R1+R2))*V_DD; // in V
15 I_D= poly(0, 'I_D')
16 V_GS= V_G-I_D*R_S; // V
17 // Evaluation the value of I.D by using polynomial
    method
18 I_D= I_D-kn*(V_GS-V_T)^2; // in mA
19 I_D= roots(I_D); // in mA
20 I_D= I_D(2); // in mA
21 I_DQ= I_D; // in mA

```

```

22 // Evaluation the value of V_DSQ,
23 V_DSQ= V_DD-I_D*(R_D+R_S); // in V
24 disp(I_DQ,"The value of I_DQ in mA is : ")
25 disp(V_DSQ,"The value of V_DSQ in volts is : ")
26 V_GS= V_G-I_D*R_S; // V
27 V_DSsat= V_GS-V_T; // in V
28 disp("The value of V_DS ( "+string(V_DSQ)+" V ) is
      greater than the value of ")
29 disp("V_DSsat ( "+string(V_DSsat)+" V ), So the
      MOSFET is in saturation region")

```

Scilab code Exa 5.24 IDSQ VGSQ and VDSQ

```

1 // Exa 5.24
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 kn= 0.5; // in mA/V^2
8 V_T= 1; // in V
9 R2 = 40; // in k ohm
10 R1 = 60; // in k ohm
11 R_S= 1; // in k ohm
12 R_D= 2; // in k ohm
13 V_DD = 5; // in V
14 V_SS = -5; // in V
15 V_R2 = (R2/(R2+R1))*(V_DD-V_SS); // in V
16 V_G = V_R2 - V_DD; // in V
17 I_D= poly(0,'I_D');
18 V_S= I_D*R_S+V_SS; // in V
19 V_GS= V_G-V_S; // in V
20 // Evaluation the value of I_D by using polynomial
      method,
21 I_D=I_D-kn*(V_GS-V_T)^2; // in mA

```



```

22 I_D= roots(I_D);// in mA
23 // Discarding I_D(1), as it will result in a
    negative V_DS
24 I_D= I_D(2);// in mA
25 I_DQ= I_D;// in mA
26 V_S= I_D*R_S+V_SS;// in V
27 V_GS= V_G-V_S;// in V
28 // The value of V_DSQ,
29 V_DSQ= V_DD-V_SS-I_D*(R_D+R_S);// in V
30 disp(I_DQ,"The value of I_DQ in mA is : ")
31 disp(V_GS,"The value of V_GS in volts is : ")
32 disp(V_DSQ,"The value of V_DSQ in volts is : ")

```

Scilab code Exa 5.25 ID VDS VGS and Av

```

1 // Exa 5.25
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 R_S1 = 100*10^-3;// in k ohm
8 R_S2 = 100*10^-3;// in k ohm
9 R_S = R_S1+R_S2;// in k ohm
10 R_D= 1.8;// in k ohm
11 I_DSS= 12;// in mA
12 Vp= -3.5;// in V
13 V_DD= 22;// in V
14 rd= 25;// in k ohm
15 R_L= 47;// in k ohm
16 I_D= poly(0,'I_D');
17 V_GS= -I_D*R_S;// in V
18 // Evaluation the value of I_D by using polynomial
    method,
19 I_D= I_D-I_DSS*(1-V_GS/Vp)^2;// in mA

```

```

20 I_D= roots(I_D);// in mA
21 // Discarding I_D(1), as it will give a negative
    result V_DS
22 I_D= I_D(2);// in mA
23 disp(I_D,"The value of I_D in mA is : ")
24 // The value of V_GS,
25 V_GS= -I_D*R_S;// in V
26 disp(V_GS,"The value of V_GS in volts is : ")
27 // The value of V_DS,
28 V_DS= V_DD-I_D*(R_D+R_S);// in V
29 disp(V_DS,"The value of V_DS in volts is : ")
30 gmo= -2*I_DSS/Vp;// in mS
31 gm= gmo*(1-V_GS/Vp);// in mS
32 miu= gm*rd;
33 // The value of Av,
34 Av= -miu*R_D*R_L/(R_D+R_L)/(rd+R_D*R_L/(R_D+R_L)+(1+
    miu)*R_S1);
35 disp(Av,"The value of Av is : ")

```

Scilab code Exa 5.26 VGS ID and VDS

```

1 // Exa 5.26
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_T = 1;// in V
8 k = 0.5;// in mA/V^2
9 R2 = 40;// in k ohm
10 R1 = 60;// in k ohm
11 R_S= 1;// in k ohm
12 R_D= 2;// in k ohm
13 V_DD = 5;// in V
14 V_G = (R2/(R2+R1))*V_DD;// in V

```

```

15 I_D= poly(0, 'I_D');
16 V_GS= V_G-I_D*R_S; // in V
17 // Evaluation the value of I_D by using polynomial
    method,
18 I_D= I_D-k*(V_GS-V_T)^2;
19 I_D= roots(I_D); // in mA
20 // For I_D(1), V_DS will be negative , so discarding
    it
21 I_D= I_D(2); // in mA
22 // The value of V_GS,
23 V_GS= V_G-I_D*R_S; // in V
24 // The value of V_DS,
25 V_DS= V_DD-I_D*(R_D+R_S); // in V
26 disp(I_D,"The value of I_D in mA is : ")
27 disp(V_GS,"The value of V_GS in volts is : ")
28 disp(V_DS,"The value of V_DS in volts is : ")

```

Scilab code Exa 5.27 Drain current and source to drain voltage

```

1 // Exa 5.27
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 R_D = 7.5; // in k ohm
8 V_T = -0.8; // in V
9 k = 0.2; // in mA/V^2
10 R2 = 50; // in ohm
11 R1 = 50; // in ohm
12 V_DD = 5; // in V
13 V_S = 5; // in V
14 V_G = (R2/(R2+R1))*V_DD; // in V
15 V_GS = V_G - V_S; // in V
16 I_D = k*((V_GS-V_T)^2); // in mA

```

```

17 disp(I_D,"Drain current in mA is");
18 V_SD = V_DD - (I_D*R_D); // in V
19 disp(V_SD,"Source to drain voltage in V is");

```

Scilab code Exa 5.28 IDQ VGSQ VD and VS

```

1 // Exa 5.28
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_Don = 5*10^-3; // in A
8 V_GSon = 6; // in V
9 V_GSth = 3; // in V
10 k = I_Don/(V_GSon-V_GSth)^2; // in A/V^2
11 R2 = 6.8; // in M ohm
12 R1 = 10; // in M ohm
13 R_S= 750; // in ohm
14 R_D= 2.2*10^3; // in ohm
15 V_DD = 24; // in V
16 R_S = 750; // in ohm
17 // Applying KVL for input circuit
18 V_G= R2*V_DD/(R1+R2); // in V
19 I_D= poly(0,'I_D');
20 V_GS= V_G-I_D*R_S; // in V
21 I_D= I_D-k*(V_GS-V_GSth)^2;
22 I_D= roots(I_D); // in A
23 I_D= I_D(2); // in A
24 I_DQ= I_D; // in A
25 V_GS= V_G-I_D*R_S; // in V
26 V_GSQ= V_GS; // in V
27 V_DSQ= V_DD-I_DQ*(R_D+R_S); // in V
28 I_D= I_D*10^3; // in mA
29 disp(I_D,"The value of I_D in mA is : ")

```

```
30 disp(V_GSQ,"The value of V_GSQ in volts is : ")
31 disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 5.29 VDD RD and VGS

```
1 // Exa 5.29
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_Don = 4*10^-3; // in A
8 V_GSon = 6; // in V
9 V_GSth = 3; // in V
10 V_DS= 6; // in V
11 I_D= I_Don; // in A
12 k = I_Don/((V_GSon-V_GSth)^2); // in A/V^2
13 V_GS= poly(0,'V_GS')
14 // Evaluation the value of V_GS by using polynomial
    method,
15 V_GS= I_D-k*(V_GS-V_GSth)^2;
16 V_GS= roots(V_GS); // in V
17 V_GS= V_GS(1); // in V
18 V_DD= 2*V_DS; // in V
19 // V_GS= V_DD-I_D*R_D
20 // Drain resistance,
21 R_D= (V_DD-V_GS)/I_D; // in ohm
22 R_D=R_D*10^-3; // in k ohm
23 disp(V_GS,"The value of V_GS in volts is : ")
24 disp(V_DD,"The value of V_DD in volts is : ")
25 disp(R_D,"The value of R_D in k is : ")
```

Scilab code Exa 5.30 Value of ID

```

1 // Exa 5.30
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_DD= 20; // in mA
8 R2 = 10; // in k ohm
9 R1 = 30; // in k ohm
10 R_S= 1.2; // in k ohm
11 R_D= 500*10^-3; // in k ohm
12 V_DD = 12; // in V
13 Vp= -6; // in V
14 V_G = (R2/(R2+R1))*V_DD; // in V
15 I_D= poly(0, 'I_D')
16 V_GS= V_G-I_D*R_S; // in V
17 // Evaluation the value of I_D by using polynomial
    method,
18 I_D=I_D-I_DD*(1-V_GS/Vp)^2;
19 I_D= roots(I_D); // in mA
20 // For I_D(1), V_DS will be negative, so discarding
    it
21 I_D= I_D(2); // in mA
22 // The value of V_DS,
23 V_DS= V_DD-I_D*(R_D+R_S); // in V
24 // The value of V_D,
25 V_D= V_DD-I_D*R_D; // in V
26 // The value of V_S,
27 V_S= V_D-V_DS; // in V
28 disp(I_D,"The value of I_D in mA is : ")
29 disp(V_DS,"The value of V_DS in volts is : ")
30 disp(V_D,"The value of V_D in volts is : ")
31 disp(V_S,"The value of V_S in volts is : ")

```

Scilab code Exa 5.31 Voltages at all nodes

```

1 // Exa 5.31
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_DD = 5; // in V
8 V_T= 1; // in V
9 k= 1; // in mA/V^2
10 R1 = 1; // in M ohm
11 R2 = 1; // in M ohm
12 R_S= 2; // in k ohm
13 R_D= 2; // in k ohm
14 // Calculation of I1
15 I1 = V_DD/(R1+R2); // in A
16 disp(I1,"The value of I1 in A is : ")
17 // The value of V_A,
18 V_A = (R2/(R2+R1))*V_DD; // in V
19 disp(V_A,"The value of V_A and V_G in volts is : ")
20 I_D= poly(0,'I_D');
21 V_C= I_D*R_S; // in V
22 V_GS= V_A-V_C; // in V
23 // Evaluation the value of I_D by using polynomial
    method,
24 I_D= I_D-k*(V_GS-V_T)^2;
25 I_D= roots(I_D); // in mA
26 // For I_D(1), V_DS will be negative, so discarding
    it
27 I_D= I_D(2); // in mA
28 disp(I_D,"The value of I_D in mA is : ")
29 // The value of V_B,
30 V_B= V_DD-I_D*R_D; // in V
31 // The value of V_C,
32 V_C= I_D*R_S; // in V
33 // The value of V_DS,
34 V_DS= V_B-V_C; // in V
35 disp(V_B,"The value of V_B in volts is : ")
36 disp(V_C,"The value of V_C in volts is : ")

```

```

37 disp(V_DS,"The value of V_DS in volts is : ")
38
39 // Note: In the book, the calculated values are not
    accurate, this is why the answer in the book is
    wrong.

```

Scilab code Exa 5.32 Av Ri Ro and Rodesh

```

1 // Exa 5.32
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_DSS = 12; // in mA
8 I_DSS= I_DSS*10^-3; // in A
9 V_P = -3; // in V
10 r_d = 45; // in k ohm
11 r_d= r_d*10^3; // in ohm
12 g_m = I_DSS/abs(V_P); // in S
13 // Part (i)
14 R1 = 91; // in M ohm
15 R1=R1*10^6; //in ohm
16 R2 = 10; // in M ohm
17 R2= R2*10^6; // in ohm
18 // Calculation to find the value of Ri
19 Ri= R1*R2/(R1+R2); // in ohm
20 Ri=Ri*10^-6; // in M ohm
21 disp(Ri,"The value of Ri in Mohm is : ")
22 // Part (ii)
23 R_S = 1.1; // in k ohm
24 R_S = R_S * 10^3; // in ohm
25 // The value of R_o,
26 R_o= (R_S*1/g_m)/(R_S+1/g_m); // in ohm
27 disp(R_o,"The value of R_C in ohm is : ")

```



```

28 // Part (iii)
29 // The value of R_desh_o
30 R_desh_o= R_o*r_d/(R_o+r_d); // in ohm
31 disp(R_desh_o,"The value of R'o in ohm is : ");
32 // Part (iv)
33 // The voltage gain can be find as ,
34 Av= g_m*(R_S*r_d/(R_S+r_d))/(1+g_m*(R_S*r_d/(R_S+r_d
    )));
35 disp(Av,"The value of Av is : ")

```

Scilab code Exa 5.34 Current flow through M1 MOSFET

```

1 // Exa 5.34
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_S2 = -2; // in V
8 V_GS2 = -V_S2; // in V
9 I_DS2 = (V_GS2-1)^2; // in mA
10 I = 2; // in mA
11 // The current flow through M1 MOSFET,
12 I_DS1 = I-I_DS2; // in mA
13 disp(I_DS1,"The current flow through M1 MOSFET in mA
    is");

```

Scilab code Exa 5.35 Value of R and VD

```

1 // Exa 5.35
2 format('v',6)
3 clc;
4 clear;

```

```

5 close;
6 // Given data
7 V_DD= 10; // in V
8 I_D= 0.4*10^3; // in A
9 W= 100; // in m
10 L= 10; // in m
11 uACox= 20; // in A/V^2
12 Vt= 2; // in V
13 R= poly(0, 'R')
14 V_GS= V_DD-I_D*R; // in V
15 // Evaluation the value of R by using polynomial
    method,
16 R= I_D-1/2*uACox*W/L*(V_GS-Vt)^2;
17 R= roots(R); // in Mohm
18 // For R(1), V_DS will be zero, so discarding it
19 R= R(2); // in Mohm
20 R=R*10^3; // in k ohm
21 disp(R,"The value of R in k is : ")
22 R=R*10^-3; // in ohm
23 // The value of V_D,
24 V_D= V_DD-I_D*R; // in V
25 disp(V_D,"The value of V_D in volts is : ")

```

Scilab code Exa 5.36 ID and VDS

```

1 // Exa 5.36
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_GStH= 2; // in V
8 k= 2*10^-4; // in A/V^2
9 V_DD= 12; // in V
10 R_D= 5*10^3; // in ohm

```

```

11 I_D= poly(0, 'I_D');
12 V_DS= V_DD-I_D*R_D; // in V
13 // Evaluation the value of I_D by using polynomial
    method,
14 I_D= I_D-k*(V_DS-V_GSth)^2;
15 I_D= roots(I_D); // in A
16 // For I_D(1), V_DS will be negative, so discarding
    it
17 I_D= I_D(2); // in A
18 // The value of V_DS,
19 V_DS= V_DD-I_D*R_D; // in V
20 I_D= I_D*10^3; // in mA
21 disp(I_D,"The value of I_D in mA is : ")
22 disp(V_DS,"The value of V_DS in volts is : ")

```

Chapter 6

Bipolar Junction Transistor

Scilab code Exa 6.1 Common base dc current gain

```
1 // Exa 6.1
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_C= 5.10; // in mA
8 I_E= 5.18; // in mA
9 alpha= I_C/I_E;
10 alpha_dc= alpha;
11 disp(alpha_dc,"The common-base d.c. current gain is
    : ")
```

Scilab code Exa 6.2 Base current

```
1 // Exa 6.2
2 format('v',6)
3 clc;
```

```

4 clear;
5 close;
6 // Given data
7 alpha= 0.987;
8 I_E= 10;// in mA
9 // Formula alpha= I_C/I_E;
10 I_C= alpha*I_E;// in mA
11 I_B= I_E-I_C;// in mA
12 disp(I_B,"The base current in mA is : ")

```

Scilab code Exa 6.3 Value of IC and IB

```

1 // Exa 6.3
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 alpha= 0.987;
8 I_E= 10;// in mA
9 // Formula alpha= I_C/I_E;
10 I_C= alpha*I_E;// in mA
11 I_B= I_E-I_C;// in mA
12 disp(I_C,"The collector current in mA is : ")
13 disp(I_B,"The base current in mA is : ")

```

Scilab code Exa 6.4 Collector and base current

```

1 // Exa 6.4
2 format('v',6)
3 clc;
4 clear;
5 close;

```

```

6 // Given data
7 Beta= 100;
8 I_E= 10;// in mA
9 alpha= Beta/(1+Beta);
10 disp(alpha,"The value of alpha is : ")
11 // Formula alpha= I_C/I_E;
12 I_C= alpha*I_E;// in mA
13 I_B= I_E-I_C;// in mA
14 disp(I_C,"The collector current in mA is : ")
15 disp(I_B,"The base current in mA is : ")
16
17 // Note: The calculated value of alpha in the book
    is wrong, due to this the answer in the book is
    wrong.

```

Scilab code Exa 6.5 Value of alpha and beta

```

1 // Exa 6.5
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 alpha= 0.950;
8 Beta= alpha/(1-alpha);
9 disp(Beta,"For alpha = 0.950, the value of beta is :
    ")
10 Beta= 100;
11 alpha= Beta/(1+Beta);
12 disp(alpha,"For beta = 100, the value of alpha is :
    ")

```

Scilab code Exa 6.6 Collector and base current

```

1 // Exa 6.6
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_E= 10;// in mA
8 Beta= 100;
9 alpha= Beta/(1+Beta);
10 // Formula alpha= I_C/I_E;
11 I_C= alpha*I_E;// in mA
12 I_B= I_E-I_C;// in mA
13 disp(I_B,"The base current in mA is : ")
14 disp(I_C,"The collector current in mA is : ")
15
16 // Note: In the book the calculated value of I_B is
    not correct , so the answer in the book is not
    accurate

```

Scilab code Exa 6.7 DC load line

```

1 // Exa 6.7
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_CC= 12;// in V
8 R_C= 3;// in k
9 V_CE= 0:0.1:12;// in V
10 I_C= (V_CC-V_CE)/R_C;// in mA
11 plot(V_CE,I_C);
12 xlabel("V_CE in volts")
13 ylabel("I_C in mA")
14 title("DC load line")

```

```
15 disp("DC load line shown in figure.")
```

Scilab code Exa 6.8 Operating point and stability factor

```
1 // Exa 6.8
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 bita= 100;
8 V_CC= 6;// in V
9 V_BE= 0.7;// in V
10 R_B= 530*10^3;// in
11 R_C= 2*10^3;// in
12 // Applying KVL for input side , V_CC= I_B*R_B+V_BE
    or
13 I_B= (V_CC-V_BE)/R_B;// in A
14 I_C= bita*I_B;// in A
15 // Applying KVL to output side ,
16 V_CE= V_CC-I_C*R_C;// in V
17 S= 1+bita;
18 disp("The operating point is : "+string(V_CE)+" V, "
    +string(I_C*10^3)+" mA")
19 disp(S,"The stability factor is : ")
```

Scilab code Exa 6.9 Collector and base current

```
1 // Exa 6.9
2 format('v',6)
3 clc;
4 clear;
5 close;
```



```

6 // Given data
7 Beta= 75;
8 V_CC= 20;// in V
9 V_BE= 0;// in V
10 R_B= 200*10^3;// in
11 R_C= 800;// in
12 // Applying KVL for input side, V_CC= I_B*R_B+V_BE
    or
13 I_B= (V_CC-V_BE)/R_B;// in A
14 I_B=I_B*10^6;// in A
15 disp(I_B,"The base current in A is : ")
16 I_B=I_B*10^-6;// in A
17 // The collector current ,
18 I_C= Beta*I_B;// in A
19 I_C=I_C*10^3;// in mA
20 disp(I_C,"The collector current in mA is : ")
21 I_C=I_C*10^-3;// in A
22 // Applying KVL to output side, the collector to
    emitter voltage
23 V_CE= V_CC-I_C*R_C;// in V
24 disp(V_CE,"The collector to emitter voltage in V is
    : ")
25 // The stability factor ,
26 S= 1+Beta;
27 disp(S,"The stability factor is : ")

```

Scilab code Exa 6.10 Base resistor and stability factor

```

1 // Exa 6.10
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 Beta= 100;

```

```

8 V_CC= 12; // in V
9 V_BE= 0; // in V
10 I_B= 0.3*10^-3; // in A
11 R_C= 300; // in
12 // Applying KVL for input side , V_CC= I_B*R_B+V_BE
    or
13 R_B= (V_CC-V_BE)/I_B; // in
14 R_B= R_B*10^-3; // in k ohm
15 disp(R_B,"The value of base resistor in k is : ")
16 I_C= Beta*I_B; // in A
17 // The collector to emitter voltage
18 V_CE= V_CC-I_C*R_C; // in V
19 disp(V_CE,"The collector to emitter voltage in V is
    : ")
20 // The stability factor ,
21 S= 1+Beta;
22 disp(S,"The stability factor is : ")

```

Scilab code Exa 6.11 DC bias voltage

```

1 // Exa 6.11
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 R_B= 400*10^3; // in
8 R_C= 2*10^3; // in
9 R_E= 1*10^3; // in
10 V_CC= 20; // in V
11 Beta= 100;
12 // Base current can be evaluated as ,
13 I_B= V_CC/(R_B+Beta*R_E); // in A
14 // Collector current
15 I_C= Beta*I_B; // in A

```

```

16 // The collector to emitter voltage
17 V_CE= V_CC-I_C*(R_C+R_E); // in V
18 I_B= I_B*10^3; // in mA
19 I_C= I_C*10^3; // in mA
20 disp(I_B,"The value of base current in mA is : ")
21 disp(I_C,"The value of collector current in mA is :
    ")
22 disp(V_CE,"The collector to emitter voltage in V is
    : ")

```

Scilab code Exa 6.12 Collector current collector to emitter voltage and stability factor

```

1 // Exa 6.12
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 R_B= 180*10^3; // in
8 R_C= 820; // in
9 R_E= 200; // in
10 V_CC= 25; // in V
11 V_BE= 0.7; // in V
12 Beta= 80;
13 // Collector current can be find as ,
14 I_C= (V_CC-V_BE)/(R_E+R_B/Beta); // in A
15 // The collector to emitter voltage
16 V_CE= V_CC-I_C*(R_C+R_E); // in V
17 I_C=I_C*10^3; // in mA
18 disp(I_C,"The value of collector current in mA is :
    ")
19 disp(V_CE,"The collector to emitter voltage in V is
    : ")
20

```

```
21 // Note: The calculated value of V_CE in the book is
    wrong.
```

Scilab code Exa 6.13 collector current and stability factor

```
1 // Exa 6.13
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 R_B= 200*10^3; // in
8 R_C= 20*10^3; // in
9 V_CC= 20; // in V
10 V_BE= 0.7; // in V
11 Beta= 100;
12 // The value of collector current
13 I_C= (V_CC-V_BE)/(R_C+R_B/Beta); // in A
14 // The collector to emitter voltage
15 V_CE= V_CC-I_C*R_C; // in V
16 // The stability factor
17 S= (1+Beta)/(1+Beta*(R_C/(R_C+R_B)));
18 I_C=I_C*10^3; // in mA
19 disp(I_C,"The value of collector current in mA is :
    ")
20 disp(V_CE,"The collector to emitter voltage in V is
    : ")
21 disp(S,"The stability factor is : ")
```

Scilab code Exa 6.14 IB IC VCE and stability

```
1 // Exa 6.14
2 format('v',6)
```

```

3  clc;
4  clear;
5  close;
6  // Given data
7  R_B= 100*10^3; // in
8  R_C= 10*10^3; // in
9  V_CC= 10; // in V
10 V_BE= 0; // in V
11 Beta= 100;
12 // Base current can be evaluated as ,
13 I_B= (V_CC-V_BE)/(R_B+R_C*Beta); // in A
14 // The value of collector current
15 I_C= Beta*I_B; // in A
16 // The collector to emitter voltage
17 V_CE= V_CC-I_C*R_C; // in V
18 // The stability factor ,
19 S= (1+Beta)/(1+Beta*(R_C/(R_C+R_B)));
20 I_C=I_C*10^3; // in mA
21 disp(I_C,"The value of collector current in mA is :
    ")
22 disp(V_CE,"The collector to emitter voltage in V is
    : ")
23 disp(S,"The stability factor is : ")
24
25 // Note: The calculated value of S in the book is
    wrong.

```

Scilab code Exa 6.15 Emitter and collector current and VCE

```

1  // Exa 6.15
2  format('v',6)
3  clc;
4  clear;
5  close;
6  // Given data

```

```

7 R_B= 50*10^3; // in
8 R_C= 1*10^3; // in
9 R_E= 5*10^3; // in
10 V_CC= 10; // in V
11 V_EE= 10; // in V
12 V_BE= 0.7; // in V
13 V_E= -V_BE; // in V
14 // The value of emitter current
15 I_E= (V_EE-V_BE)/R_E; // in A
16 // The collector current will be equal to emitter
    current
17 I_C= I_E; // in A
18 // The collector to emitter voltage
19 V_CE= V_CC-I_C*R_C; // in V
20 V_CE= V_CE-V_E; // in V
21 I_C=I_C*10^3; // in mA
22 I_E=I_E*10^3; // in mA
23 disp(I_E,"The value of emitter current in mA is : ")
24 disp(I_C,"The value of collector current in mA is :
    ")
25 disp(V_CE,"The collector to emitter voltage in V is
    : ")

```

Scilab code Exa 6.16 Change in Q point

```

1 // Exa 6.16
2 format('v',5)
3 clc;
4 clear;
5 close;
6 // Given data
7 R_B= 10*10^3; // in
8 R_C= 5*10^3; // in
9 R_E= 10*10^3; // in
10 Beta=50;

```

```

11 V_CC= 20; // in V
12 V_EE= 20; // in V
13 V_BE= 0.7; // in V
14 V_E= -V_BE; // in V
15 // The value of I_E1 ,
16 I_E1= (V_EE-V_BE)/(R_E+R_B/Beta); // in A
17 I_C1= I_E1; // in A
18 V_C= V_CC-I_C1*R_C; // in V
19 V_CE1= V_C-V_E; // in V
20 Beta= 100;
21 V_BE= 0.6; // in V
22 V_E= -V_BE; // in V
23 // The value of I_E2 ,
24 I_E2= (V_EE-V_BE)/(R_E+R_B/Beta); // in A
25 I_C2= I_E2; // in A
26 V_C= V_CC-I_C2*R_C; // in V
27 V_CE2= V_C-V_E; // in V
28 // The change in collector current
29 delta_IC= (I_C2-I_C1)/I_C1*100; // in %
30 // The change in collector to emitter voltage
31 delta_V_CE= (V_CE1-V_CE2)/V_CE1*100; // in %
32 disp(delta_IC,"The change in collector current in %
    is : ")
33 disp(delta_V_CE,"The change in collector to emitter
    voltage in % is : ")

```

Scilab code Exa 6.18 Value of α_{DC} and emitter current

```

1 // Exa 6.18
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 I_CBO = 3; //in A

```

```

8 I_CB0= I_CB0*10^-3; // in mA
9 I_C= 15; // in mA
10 // But it is given that I_C= 99.5% of I_E, SO
11 I_E= I_C/99.5*100; // in mA
12 alpha_dc= I_C/I_E;
13 disp(alpha_dc,"The value of alpha_dc is : ")
14 disp(I_E,"The value of I_E in mA is : ")

```

Scilab code Exa 6.19 IC and IB

```

1 //Exa 6.19
2 format('v',6)
3 clc;
4 clear;
5 close;
6 //Given data
7 alpha_dc = 0.99;
8 I_CB0 = 10; // in A
9 I_CB0= I_CB0*10^-6; // in A
10 I_E = 10; // in mA
11 I_E= I_E*10^-3; // in A
12 // The collector current can be find as ,
13 I_C = (alpha_dc * I_E) + I_CB0; // in A
14 I_C=I_C*10^3; // in mA
15 disp(I_C,"The value of I_C in mA is");
16 I_C=I_C*10^-3; // in A
17 // Calculation to find the value of base current
18 I_B = I_E - I_C; // in A
19 I_B = I_B * 10^6; // in A
20 disp(I_B,"The value of I_B in A is");

```

Scilab code Exa 6.20 Base current


```

1 // Exa 6.20
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 alpha_dc = 0.99;
8 I_C = 6; // in mA
9 I_C= I_C*10^-3; // in A
10 I_CBO = 15; // in A
11 I_CBO= I_CBO*10^-6; // in A
12 // The emitter current,
13 I_E = (I_C - I_CBO)/alpha_dc; // in A
14 // The base current,
15 I_B = I_E - I_C; // in A
16 I_B=I_B*10^6; // in A
17 disp(I_B,"The value of I_B in A is");

```

Scilab code Exa 6.22 Emitter current

```

1 //Exa 6.22
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 alpha_dc = 0.98;
8 I_CBO = 12; // in A
9 I_CBO = I_CBO * 10^-6; // in A
10 I_B = 120; // in A
11 I_B = I_B * 10^-6; // in A
12 beta_dc = alpha_dc/(1-alpha_dc);
13 I_E = ((1 + beta_dc) * I_B) + ((1 + beta_dc) * I_CBO
    ); //in A
14 I_E = I_E * 10^3; // in mA

```

```
15 disp(I_E,"The value of I_E in mA is");
```

Scilab code Exa 6.23 Region of operation

```
1 //Exa 6.23
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 bita= 100;
8 V_BEsat= 0.8; // in V
9 V_CEsat= 0.2; // in V
10 V_BEact= 0.7; // in V
11 V_CC = 10; // in V
12 V_BB=5; // in V
13 R_E = 2; // in k
14 R_C = 3; // in k
15 R_B= 50; // in k
16 // Applying KVL to collector loop
17 // V_CC= I_Csat*R_C +V_CEsat +I_E*R_E and I_E=
    I_Csat+I_B, So
18 //I_B= ((V_CC-V_CEsat)-(R_C+R_E)*I_Csat)/R_E;
    (i)
19 // Applying KVL to base loop
20 // V_BB-I_B*R_B -V_BEsat-I_E*R_E =0 and I_E= I_Csat+
    I_B, So
21 //V_BB-V_BEsat= R_E*I_Csat + (R_B+R_E)*I_B
    (ii)
22 // From eq (i) and (ii)
23 I_B = ((V_BB-V_BEsat)*5- (V_CC-V_CEsat)*2) / ((R_B+
    R_E)*5 - R_E*2) ; // in mA
24 I_Csat= ((V_CC-V_CEsat)-R_E*I_B)/(R_C+R_E); // in mA
25 I_Bmin= I_Csat/bita; // in mA
26 if I_B<I_Bmin then
```

```

27     disp(" Since the value of I_B (" + string(I_B*10^3)
        + " A ) is less than the value of I_Bmin (" +
        string(I_Bmin*10^3) + " A )");
28     disp(" So the transistor is not in the saturation
        region. But it is conducting hence it can
        not be in cutoff.")
29     disp(" Therefore the transistor is in the active
        region")
30 end

```

Scilab code Exa 6.24 IB IC and VCE

```

1 //Exa 6.24
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 Beta= 100;
8 V_BEsat= 0.8; // in V
9 V_CEsat= 0.2; // in V
10 V_BEact= 0.7; // in V
11 V_CC = 10; // in V
12 V_BB=5; // in V
13 R_E = 2; // in k
14 R_C = 3; // in k
15 R_B= 50; // in k
16 // Applying KVL to input loop
17 // V_BB= I_B*R_B+(1+Beta)*I_B*R_E+V_BEact or
18 I_B= (V_BB-V_BEact)/(R_B+(1+Beta)*R_E); // in mA
19 // The collector current ,
20 I_C= Beta*I_B; // in mA
21 // Applying KVL to collector circuit
22 // V_CC= I_Csat*R_C +V_CEsat +(I_C+I_B)*R_E
23 V_CEact= V_CC-I_B*R_E-I_C*(R_C+R_E); // in V

```

```

24 // The base current ,
25 I_B= I_B*10^3; // in A
26 disp(I_B,"The value of I_B in A is : ")
27 disp(I_C,"The value of I_C in mA is : ")
28 disp(V_CEact,"The value of V_CE in volts is : ")

```

Scilab code Exa 6.25 Region of operation

```

1 //Exa 6.25
2 format('v',6)
3 clc;
4 clear;
5 close;
6 //Given data
7 Beta = 100;
8 V_CEsat = 0.2; // in V
9 R_B = 150; // in k ohm
10 R_C = 2; // in k ohm
11 V_CC = 10; // in V
12 V_BEsat = 0.8; // in V
13 I_B = (V_CC - V_BEsat)/R_B; // in mA
14 I_C = (V_CC - V_CEsat)/R_C; // in mA
15 I_Bmin = I_C/Beta; // in mA
16 I_B=I_B*10^3; // in A
17 I_Bmin=I_Bmin*10^3; // in A
18 if I_B>I_Bmin then
19     disp("Since the value of I_B (" + string(I_B) + " A
20         ) is greater than the value of I_Bmin (" +
21         string(I_Bmin) + " A)");
22     disp("So the transistor is in the saturation
23         region.")
24 end

```

Scilab code Exa 6.26 Value of VBB

```
1 //Exa 6.26
2 format('v',6)
3 clc;
4 clear;
5 close;
6 //Given data
7 Beta = 100;
8 V_CE = 0.2; //in V
9 V_BE = 0.8; // in V
10 R_C= 500; // in
11 R_B= 44*10^3; // in
12 R_E= 1*10^3; // in
13 V_CC= 15; // in V
14 V_GE= -15; // in V
15 // Applying KVL to collector circuit , V_CC-V_GE -
    I_Csat*R_C-V_CE-I_E*R_E=0, but I_Csat= Beta*
    I_Bmin and I_E= 1+Beta
16 // Minimum value of base current ,
17 I_Bmin= (V_CC-V_GE-V_CE)/(R_C*Beta+(1+Beta)*R_E); //
    in A
18 // Applying KVL to the base emitter circuit , V_BB-
    I_Bmin*R_B-V_BE-I_E*R_E + V_CC=0
19 // The value of V_BB,
20 V_BB= I_Bmin*R_B + V_BE + (1+Beta)*I_Bmin*R_E-V_CC;
    // in V
21 I_Bmin= I_Bmin*10^3; //in mA
22 disp(I_Bmin,"The value of I_B(min) in mA is : ")
23 disp(V_BB,"The value of V_BB in volts is : ")
```

Scilab code Exa 6.27 Minimum value of RC required

```
1 // Exa 6.27
2 format('v',6)
```

```

3  clc;
4  clear;
5  close;
6  // Given data
7  V_ECsat= 0.2; // in V
8  V_CC= 10; // in V
9  V_EBsat= 0.8; // in V
10
11 // Part (i)
12 Beta= 100;
13 R_B= 220; // in k
14 // Applying KVL to collector circuit , V_CC= V_EC+
    ICRC
15 ICRC= V_CC-V_ECsat; // in V
16 // Applying KVL to input loop , V_CC= V_EBsat+I_B*R_B
    (i)
17 I_B= (V_CC-V_EBsat)/R_B; // in mA
18 I_C= Beta*I_B; // in mA
19 R_Cmin= ICRC/I_C; // in k
20 disp(R_Cmin,"The minimum value of R_C in k is : "
    )
21 // Part (ii)
22 R_C= 1.2; // in k
23 I_Csat= ICRC/R_C; // in mA
24 I_B= I_Csat/Beta; // in mA
25 // From eq (i)
26 R_B= (V_CC-V_EBsat)/I_B; // in k
27 disp(R_B,"The maximum value of R_B in k is : ")

```

Scilab code Exa 6.28 Value of RE

```

1 //Exa 6.28
2 format('v',6)
3 clc;
4 clear;

```

```

5  close;
6  // Given data
7  Beta= 100;
8  V_BEsat= 0.8; // in V
9  V_CEsat= 0.2; // in V
10 V_BEact= 0.7; // in V
11 V_CC = 10; // in V
12 R_E = 1; // in k
13 R_C = 2; // in k
14 R_B= 100; // in k
15 Beta=100;
16 alpha= Beta/(1+Beta);
17 // Applying KVL to collector circuit
18 // V_CC= I_Csat*R_C +V_CE +R_E*I_E
19 // but I_E= alpha*I_Csat
20 I_Csat= (V_CC-V_CEsat)/(R_C+R_E*alpha); // in mA
21 I_Bmin= I_Csat/Beta; // in mA
22 // Applying KVL to base loop
23 // V_CC= I_B*R_B +V_BEsat +I_E*R_E
24 // but I_E= I_Csat+I_B
25 I_B= (V_CC-V_BEsat-I_Csat*R_E)/(R_B+R_E); // in mA
26 I_B=I_B*10^3; // in A
27 disp(I_B,"The value of I_B in A is : ")
28 I_B=I_B*10^-3; // in mA
29 I_Bmin= I_Bmin*10^3; // in A
30 disp(I_Bmin,"The minimum value of I_B in A is : ")
31 I_Bmin= I_Bmin*10^-3; // in mA
32 if I_B>I_Bmin then
33     disp("Since the value of I_B is greater than the
           value of I_Bmin, ")
34     disp("Hence the transistor is in saturation .")
35 end
36 // The emitter current ,
37 I_E= (1+Beta)*I_Bmin; // in mA
38 // The value of R_E
39 R_E= (V_CC-V_BEact-I_Bmin*R_B)/I_E; // in k
40 disp(R_E,"The value of R_E in k is : ")
41 disp("So R_E should be greater than this value in

```

order to bring the transistor just out of saturation ")

Scilab code Exa 6.29 Collector voltage

```
1 // Exa 6.29
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 V_CC = 9; // in V
8 V_BE = 0.8; // in V
9 V_CE = 0.2; // in V
10 R_B = 50; // in k
11 R_C=2; // in k
12 R_E = 1; // in k
13 Beta=70;
14 // Applying KVL to input loop, V_CC= I_B*R_B +V_BE +
    I_E*R_E
15 // V_CC- V_BE= (R_B+R_E)*I_B + R_E*I_C (i)
16 // Applying KVL to output loop, V_CC= R_C*I_C +V_CE
    +I_C*R_E +I_B*R_E
17 //I_B = ((V_CC- V_CE)-(R_C+R_E)*I_C)/R_E (ii)
    )
18 // From eq (i) and (ii)
19 I_C= ( (V_CC- V_BE)-(R_B+R_E)* (V_CC- V_CE)/R_E)
    /(1-(R_B+R_E)*(R_C+R_E)); // in mA
20 I_B = ((V_CC- V_CE)-(R_C+R_E)*I_C)/R_E // in mA
21 I_Bmin= I_C/Beta; // in mA
22 if I_B>I_Bmin then
23     disp(" Since the value of I_B (" +string(I_B)+ " mA
        ) is greater than the value of I_Bmin (" +
        string(I_Bmin)+ " mA)")
24     disp(" So the transistor is in saturation ")
```



```
25 end
26 V_C= V_CC-I_C*R_C; // in V
27 disp(V_C,"The value of collector voltage in volts is
      : ")
28 Beta= I_C/I_B;
29 disp(Beta,"The minimum value of beta that will
      change the state of the transistor is : ")
```

Chapter 7

Optoelectronic Devices

Scilab code Exa 7.1 Component value

```
1 // Exa 7.1
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 O_V = 5; // output voltage in V
8 V_D = 1.5; // voltage drop in V
9 R = (O_V - V_D)/O_V;
10 R = R * 10^3; // in ohm
11 disp(R,"The resistance value in      is");
12 disp("As this is not standard value , use R=680
      which is a standard value")
```

Scilab code Exa 7.2 Open circuit voltage

```
1 // Exa 7.2
2 format('v',6)
```

```

3  clc;
4  clear;
5  close;
6  // Given data
7  N_A = 7.5*10^24; // in atoms/m^3
8  N_D = 1.5*10^22; // in atoms/m^3
9  D_e = 25*10^-4; // in m^2/s
10 D_h = 1*10^-3; // in m^2/s
11 Torque_eo = 500; // in ns
12 Torque_ho = 100; // in ns
13 n_i = 1.5*10^16; // in /m^3
14 e = 1.6*10^-19; // in C
15 P_C = 12.5; // in mA/cm^2
16 // Electron diffusion length
17 L_e = sqrt(D_e*Torque_ho*10^-9); // in m
18 L_e = L_e * 10^6; // in m
19 // hole diffusion length
20 L_h = sqrt(D_h*Torque_ho*10^-9); // in m
21 L_h = L_h * 10^6; // in m
22 // The value of J_s can be calculated as,
23 J_s = e*((n_i)^2)*((D_e/(L_e*10^-6*N_A)) + (D_h/(
    L_h*10^-6*N_D))); // in A/m^2
24 J_s = J_s * 10^3; // in A/cm^2
25 V_T = 26; // in mV
26 I_lambda = 12.5*10^-3;
27 I_s = 2.4*10^-4;
28 // Open circuit voltage
29 V_OC = V_T*log( 1+(I_lambda/J_s) ); // in mV
30 V_OC = V_OC * 10^-3; // in V
31 disp(V_OC,"Open circuit voltage in V is");
32
33 // Note: There is calculation error to evaluate the
    value of VOC since 26*10^-3*log
    (1+12.5*10^-3/2.4*10^-4) calculated as 0.10318
    not 0.522 V

```

Scilab code Exa 7.3 Photocurrent density

```
1 // Exa 7.3
2 format('v',6)
3 clc;
4 clear;
5 close;
6 // Given data
7 Phi_o = 1*10^21; // in m^-2s^-1
8 Alpha = 1*10^5; // in m^-1
9 W = 25; // in m
10 W = W * 10^-6; // in m
11 e = 1.6*10^-19; // in C
12 // At the front edge of intrinsic region, the
    generation rate of EHP
13 G_L1 = Alpha*Phi_o; // in m^-3s^-1
14 // At the back edge of intrinsic region, the
    generation rate of EHP
15 G_L2 = Alpha*Phi_o*%e^(-Alpha*W); // in m^-3s^-1
16 // Photo current density,
17 J_L = e*Phi_o*(1-%e^(-Alpha*W)); // in A/m^2
18 J_L = J_L * 10^-1; // in mA/cm^2
19 disp(J_L,"Photo current density in mA/cm^2 is");
```
