Scilab Textbook Companion for Electronic Devices and Circuits by I. J. Nagrath[1]

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 1

SEMICONDUCTORS DIODE AND DIODE CIRCUITS

Scilab code Exa 1.1 `Example`

```
//Variable declaration
A=6.022*10**23       //avagadro's number(/m^3)
d=2.7*10**6          //density of aluminium conductor(g/m^3)
a=26.98              // atomic weight aluminium conductor(g/g-atom)
D=10**4.             //current density(A/m^2)
e=1.6*10**-19        //electronic charge(C)

//Calculations
//Part a
n=A*d/a              //number of atoms(n/m^3)

//Part b
u=D/(n*e)            //drift velocity (m/s)

//Results
printf ("number of atoms per cubic meter is %.3f *10**28/m^3",n/10**28)
```

```
printf ( "drift velocity is %.2e m/s",u)
```

Scilab code Exa 1.2 Example

```
//Variable declaration
n=10**23           //number of electrons(n/m^3)
e=1.6*10**-19      //electronic charge(C)
u=0.4              //mobility(m^2/Vs)
a=10**-7           //cross sectional area(m^2)
l=15*10**-2        //conductor length(m)

//Calculations
//Part a
G=n*e*u            //conductivity(S/m)

//Part b
R=l/(a*G)          //resistance(ohm)

//Results
printf ("conductivity of the conductor is %.1e S/m", G)
printf ("resistance of the conductor is %.1f ohm",R)
```

Scilab code Exa 1.3 Example

```
//Variable declaration
A=6.022*10**23      //avagadro's number
d=5.32*10**6        //density of Ge at 300k(g/m^3)
a=72.60             //atomic weight of Ge(g/g-atom)
e=1.6*10**-19       //electronic charge(C)
ni=2.4*10**19       //intrinsic concentration(electron-hole pairs/m^3)
un=0.39             //electron mobility(m^2/V.s)
```

```
up=0.19              //hole mobility(m^2/V.s)

//Calculations
//Part a
nA=A*d/a             //number of atoms(nA/m^3)using avagadro's law
x=nA/ni              //Germanium atoms/electron hole pair

//Part b
g=(un+up)*e*ni       //intrinsic conductivity(S/m)
r=1/g                //intrinsic resistivity(ohm.m)

//Results
printf ("the relative concentration of Ge and electron hole pairs is %.2e atoms/electron-hole pair",x)
printf ("the intrinsic resistivity of Ge is %.3f ohm.m",r)
```

Scilab code Exa 1.4 Example

```
//Variable declaration
ni=1.5*10**16        //intrinsic concentration(electron-hole pairs/m^3)
n=4.99*10**28        //number of Si atoms(atoms/m^3)
un=0.13              //electron mobility(m^2/V.s)
up=0.05              //hole mobility(m^2/V.s)
e=1.6*10**-19        //electronic charge(c)

//Calculation
//Part a
g=e*ni*(un+up)      //intrinsic conductivity(S/m)
r=1/g               //interinsic resistivity(ohm.m)
Nd=n/10**8          //doped silicon(atoms/m^3)=nn,
```

```
    majority carriers
pn=ni**2/Nd     //minority carrier density(holes/m
    ^3)

//Part b
k=e*un*Nd       //conductivity(S/m)
                //using Nd in place of nn as Nd=nn
rho=1/k         //resistivity(ohm.m)

//Results
printf ("the minority carrier density of Si is %.2e
    holes/m^3 ",pn)
printf ("the resistivity of Si is %.2e ohm.m",rho)
```

Scilab code Exa 1.5 Example

```


//Variable declaration
Vo=0.7                    //contact potential(V)
Vf=0.4                    //forward biasing voltage(V)

//Calculation
x=exp(-20*(Vo-Vf))/exp(-20*Vo)    //increase in
    probability of majority carriers

//Result
printf ("increase in probability of majority
    carriers is %.f times",x)
```

Scilab code Exa 1.6 Example

```

```

```
//Variable declaration
I=10     //Ge diode carries current(mA)
V=0.2    //forward bias voltage(V)

//Calculation
//Part a
Is=I/(exp(40*V)-1)        //reverse current(mA)

//part b
I1=1*10**3
V1=(log(1/3.355*10**3 + 1))/40        //voltage(V)
I2=100*10**-3                          //current(mA)
V2=(log(100/3.355*10**3+1))/40        //voltage(V)

//Part c
Is1=4*Is                 //reverse saturation current doubles for every 10 degree celcius temp rise,so for 20 degree rise it will be 4 timese/
x=37.44                  //let x=e/kT
I3=Is1*(exp(x*V)) //current when temp doubles(mA)

//Results
printf ("the reverse current is %.3f mA",Is/1e-3)    //incorrect units given in the textbook
printf ("bias voltages are %.3f V and %.3f V resp",V1,V2)
printf ("Is at 20 degree is %.2f uA and diode current at 0.2 V is %.2f mA",Is1/1e-3,I3)
```

Scilab code Exa 1.7 Example

```
//Variable declaration
V=3.             //Voltage(V)
Req=300.         //total resistance as per circuit(
```

```
   ohm)
Rfa=20              //forward resistance(ohm)
Vt=0.7             //Thevinine's voltage(V)
Rfb=0               //forward resistance(ohm)

//Calculations
//Part a
I=V/Req             //current(A)

//Part b
Id=(V-Vt)/Req    //diode current(mA)

//Part c
Rf=20                   //forward resistance(ohms)
Id1=(V-Vt)/(Req+Rfa) //diode current(mA)

//Results
printf ("current in this case is %.2f A",I)
printf ("diode current is %.2f mA",(Id/1E-3))
printf ("diode current is %.2f mA" ,(Id1/1E-3))
```

Scilab code Exa 1.9 Example

```
//Variable declaration
Vx=1.4                  //voltage at point X(V)
Vt=0.7                  //diode voltage(V)
Vcc=5                   //cathode voltage(V)
R=1                     //circuit resistance(ohm)
Vs=Vx-Vt                //supply voltage(V)

//Calculations
I1=(Vcc-Vt-Vs)/R        //current throgh D1(mA) for 0<
   Vs<0.7
I2=0                    //current through D2 and D3
I1=(Vcc-Vt-Vs)/R    //for Vs>0.7 as D2 and D3
```

```
    conducts

//Results
printf ("I1 for 0<Vs<0.7 is %.1f mA",I1)
printf ("I2 for 0<Vs<0.7 is %.1f mA",I2)
printf ("I1 and I2 for Vs>0.7 is %.1f mA",I1)
```

Scilab code Exa 1.11 Example

```
//Variable declaration
Vz=100           //zener voltage(V)
Rz=25            //diode resistance(ohm)
Il=0.05          //load current(A)
Iz=0.01          //zener diode current(A)
Rs=250           //supply resistance(ohm)

//Calculations
Vl=Vz+(Iz*Rz)      //load voltage(V)
Vs=Vl+(Il+Iz)*Rs   //supply voltage(V)
VL=Vl*1.01         //increase in Vl(V)
IZ=(VL-Vz)/Rz      //increase in zener current
VS=Vl+(Il+IZ)*Rs   //increase in supply voltage(V)
Vss=(VS-Vs)/Vs     //%increase in supply voltage(V)
P=Il*VL            //power consumed(W)

//Results
printf ("load voltage is %.2f V",Vl)
printf ("supply voltage is %.2f V",Vs)
printf ("increase in supply voltage is %.3f V",VS)
printf ("power consumed is %.2f W",P)
```

Scilab code Exa 1.12 Example

```
//Variable declaration
Vbb=5               //bias voltage(V)
Rl=1                //resistance(ohm)
Id=4.4              //from the figure(mA)

//Part a
i=Vbb/Rl            //load line intercepts the Id axis
   at i(mA)
Vl=Id*Rl            //load voltage(V)

//Part b
Vd=Vbb-Vl           //diode voltage(V)
P=Vd*Id             //power absorbed in diode(mW)

//Part c
Ida=1.42             //diode current(mA)for 2V
Idb=7.35             //diode current(mA)for 8V

//Part d
Idc=8.7             //diode current(mA)for Rl=0.5k ohm
Idd=2.2             //diode current(mA)for Rl=2k ohm

//Results
printf ("diode current is %.1f mA and voltage across
    the load is %.1f V", Id,Vl)
printf ("power absorbed in diode is %.2f mW",P)
printf ("diode current for Vbb=2V is %.2f mA and for
    Vbb=8V is %.2f mA",Ida,Idb)
printf ("diode current for Rl=0.5 kohm is %.1f mA
   and for Rl=2 kohm is %.1f mA",Idc,Idd)
```

Scilab code Exa 1.13 Example

```
//Variable declaration
T=300                 //temperature(k)
```

```
Ig=100*10**-3          //current(mA)
Is=1*10**-9            //current(nA)
x=0.0259               //x=kT/e

//Calculations
Voc=x*log(Ig/Is+1)       //as Voc=kT/e*ln((Ig/Is)+1) where ln((Ig/Is)+1)=18.42 after solving
Isc=Ig

//Result
printf ("for a solar cell Voc is %.3f V and Isc is %.f mA",Voc,Isc/1E-3)
```

Scilab code Exa 1.14 Example

```


//Variable declaration
Idc=0.1                //dc current(A)
Rf=0.5                 //forward resistance(ohms)
Rl=20                  //load resistance(ohm)
Rs=1                   //secondary resistance of transformer(ohm)

//Calculations
//Part a
Vdc=Idc*Rl                               //dc voltage(V)
Vm=(%pi/2)*(Vdc+Idc*(Rs+Rf)) //mean voltage(V)
Vrms=Vm/sqrt(2)                   //rms value of voltage(V)

//Part b
Pdc=Idc**2*Rl                          //dc power supplied to the load

```

```
//Part c
PIV=2*Vm                          //PIV rating for each diode(V)

//Part d
Im=(%pi/2)*Idc                    //peak value of current(mA)
Irms=Im/sqrt(2)                   //rms calue of current(A)
Pac=Irms**2*(Rs+Rf+Rl)            //ac power input(W)

//Part e
eta=(Pdc/Pac)*100                 //conversion efficiency

//Part f
Vr=((Rs+Rf)/Rl)*100               //voltage regulation(V)

//results
printf ("rms value of voltage is %.2f V",Vrms)
printf ("dc power supplied to load is %.1f W",Pdc)
printf ("PIV rating for each diode %.2f V",PIV)
printf ("ac input power is %.3f W",Pac)
printf ("conversion efficiency %.1f %%",eta)
printf ("voltage regulation %.1f %%",Vr)
```

Scilab code Exa 1.15 Example

```

//Variable declaration
Vt=1
Vl=12
Vm=63.63                          //peak voltage(V) as Vm=sqr root of 2*45
Idc=8.                            //charging current(A)
```

```

//Calculations
//Part a
theta1= asind((Vt+Vl)/Vm)
theta2=180-theta1
//Rl=((2*Vm*cos(theta1))-(2*(%pi-2*theta1)*(Vt+Vl)))/(Idc*%pi)
Rl=(2*sqrt(2)*45*cosd(11.8) - (2*(%pi-2*0.206)*(Vt+Vl)))/(Idc*%pi)

function ans = ft(wt)
    ans =(((((sqrt(2)*45*sin(wt))-(Vt+Vl))/Rl)*wt)**2)
endfunction
//Part b
integ = intg(theta1,theta2,ft)
disp ( integ)
Irms = (integ/%pi)**0.5
Pl=Irms**2*Rl                          //power loss in resistance(W)

//Part c
P=Vl*Idc                               //power supplied to battery(W)

//results
printf ("Resistance to be added is %.2f Ohms",Rl)
printf ("power supplied to battery is %.f W",P)
```

Scilab code Exa 1.16 Example

```


//Variable declaration
Rf=5                              //forward resistance(ohms)
```

```
Vo=20                    //output voltage(V)
Rs=10                    //secondary resistance of transformer(ohm)

//Calculations
//Part a
Idc=0.1                  //dc current(A)
Vm=Vo*(sqrt(2))     //mean voltage(V)
Vdc=(2*Vm/(%pi))-Idc*(Rs+2*Rf)  //dc voltage(V)

//Part b
Idc1=0.2                 //full load dc current(A)
Vdc2=((2*(sqrt(2))*Vo)/(%pi))-Idc1*(Rs+2*Rf) //full load dc voltage(V)
Rl=Vdc2/Idc1              //load resistance(ohm)
x=((2*Rf+Rs)/Rl)*100      //% regulation

//Part c
Idc=0.2                   //dc current(A)
Im=(%pi)*Idc/2        //peak current(mA)
Ilrms=Im/sqrt(2)     //rms current(mA)
Vlrms=Ilrms*Rl            //load rms voltage(V)

//Part d
Vldc=14                                    //load dc voltage(V)
Vlacrms=sqrt(Vlrms**2-Vldc**2)   //rms value of ac component(V)

//Results
printf ("dc voltage %.f V",Vdc)
printf ("regulation is %.2f %%",x)
printf ("rms value of output voltage at dc load current is %.2f V",Vlrms)
printf ("rms value of ac component of voltage %.2f V",Vlacrms)
```

Scilab code Exa 1.17 Example

```
//Variable declaration
Vh=60.              //higher output voltage(V)
Vl=45.              //lower output voltage(V)
fz=50.              //frequency(Hz)
Vr=15.              //peak to peak ripple voltage(V)
Rl=600.             //resistance(ohms)

//Calculations
Vldc=(Vh+Vl)/2      //avg load dc voltage(V) as voltage
    drops from 60 to 45
Idc=Vldc/Rl         //dc current(A)
T=1/fz              //discharging time(ms)
C=(Idc*T)/Vr        //linear discharge rate(uF)
C1=C*2              //new capacitance(uF)

Vr1 = (20*120*1000)/(1200*254)
Idc1=(Vh-(Vr1/2))/Rl                  //dc load current
   (mA)

//Results
printf ("value of capacitance is %.f uF",C/1E-6)
printf ("Vr1 is %d V" ,Vr1)
printf ("dc load current Idc is %.f mA",Idc1/1E-3)
printf("Note : Answer may be vary because of
   rounding off error.")
```

Scilab code Exa 1.18 Example

```
//Variable declaration
Vdc=30                              //dc voltage(V)
V1=220                              //source voltage(V)
f=50                                //frequency(Hz)
Rl=1000                             //load resistance(k
    ohms)
Vr = 15

//Calculations
C=100/f*Rl                          //as Vdc/Vr=100
Vm=Vdc+0.01*(30/2)                       //peak voltage(
    V)
V2=Vm/(sqrt(2))                  //secondary voltage(V)
r=V1/V2                             //transformer turn
    ratio

//Results
printf ("capacitor filtor is %.f uF",C)
printf ("transformer turn ratio is %.2f",r)
```

Scilab code Exa 1.19 Example

```


//Variable declaration
Idc=60*10**-3                          //dc current(A)
Vm=60                                  //peak volage(V)
f=50                                   //frequency(Hz)
C=120*10**-6                           //capacitance(F)

//Calculations
//Part a
Vrms=Idc/(4*(sqrt(3))*f*C*Vm)  //rms voltage(V)
Vr=2*(sqrt(3))*Vrms              //ripple factor(V)

```

```
//Part b
Vdc=Vm-(Vr/2)                              //by simplifying
Vdc = 57.6                                 // V
//Part c
r=(Vrms/Vdc)*100                           //ripple factor

//Results
printf ("ripple factor is %.3f Vdc",Vr)
printf ("dc voltage is %.1f V",Vdc)
printf ("ripple factor %.3f %%",r)
```

Scilab code Exa 1.20 `Example`

```


//Calculations
//Part a
//     200*1.141         4
//v1(t)=---------------(1- - cos628t)
//          3.14          3
//        200*1.141       800*1.141
//v2(t)=------------- - ------------- cos(628t+<(V2/V1))
//           3.14            3*3.14
//
//V2/V1|w=0 =0.8;V2/V1|w=628 =6.43*10^-4 <V2/V1|w=628 =180
//v2(t)=72.02+0.0538 cos628t


//Part b
vrms=0.0538
vdc=sqrt(2)*72.02
r=vrms/vdc

```

```
//Results
printf ("ripple factor is %.2e",r)
```

Scilab code Exa 1.24 Example

```


//Variable declaration
Vz=2                    //zener voltage(V)
r1=10                   //resistance after reducing circuit by thevinin(ohms)
r2=20                   //resistance after reducing circuit by thevinin(ohms)
V1=7.5                  //voltage after circuit reduction(V)
V2=15                   //voltage after circuit reduction(V)
Rz=100/3                //zener resistance(ohms)

//Calculations
Vab=V2-(((V2-V1)/(r1+r2))*r2)          //thevinin voltage at ab(V)
Rth=(Vab*r2)/(Vab+r2)                  //thevinin resistance at ab(ohms)
Vd=Vab-Vz                              //diode voltage(V)
Id=Vd/(Rth+Rz)                         //diode current(A)

//Results
printf ("diode current is %.2f A",Id)
```

Scilab code Exa 1.25 Example

```
//Variable declaration
Vd=0.7                          //diode voltage(V)
Ro=18                           //output resistance(k ohms)
R1=2                            //diode1 resistance(k ohms)
R2=2                            //diode2 resistance(k ohms)

//Calculations
//Part a
V1=10                           //voltage to D1(V)
V2=0                            //voltage to D2(V)
Io=(V1-Vd)/(R1+Ro)              //output current(mA)
Vo=Io*Ro                        //output voltage(V)

//Part b
V1=5                            //voltage to D1(V)
V2=0                            //voltage to D2(V)
Io=(V1-Vd)/(R1+Ro)              //output current(mA)
Vo1=Io*Ro                       //output voltage(V)

//Part c
V1=10                          //voltage to D1(V)
V2=5                           //voltage to D2(V)
Vo=8.37                        //as D1 only conducts,so, Vo is same as in part a
Vd1=V2-Vo                      //assume D1 conducts
Vo2=8.37                       //D2 does not conduct as as Vd1 is negative

//Part d
V1=5 ; V2=5                      //voltage to D1 and D2(V)
Id1=(V1-Vd-Vo)/2           //diode1 current(mA)
Io=Vo/Ro                   //output current(mA)
Vo3=(Ro*(V1-Vd))/(Ro+1)    //output voltage(V)

```

```
printf ("a)output voltage is %.2f V",Vo)
printf ("b)output voltage is %.2f V",Vo1)
printf ("c)output voltage is %.2f V",Vo2)
printf ("d)output voltage is %.2f V",Vo3)
```

Scilab code Exa 1.26 Example

```
//Variable declaration
Vs=10.                          //supply voltage(V)
Rs=1                            //supply resistane(ohm)
Vl=10.                          //load voltage(V)
Vi=50.                          //nput voltage(V)
Iz=32                           //zener diode current(mA)
Is=40                           //supply current(mA)

//Calculations
//Part a (Rl is min when Iz=0)
Is=(Vi-Vs)/Rs                  //source current(mA)
Rlmin=Vl/(Vi-Vs)               //load resistance minimum(ohm)

//Part b(Rl is maximum when Iz=32 mA)
Il=(Is-Iz)*10**-3             //load current(A)
Rlmax=Vl/Il                   //maximum load resistance (k ohms)
P=Vl*Iz                       //max diode wattage consumed(mW)

//Results
printf ("Range of Rl is %.2f ohm to %.2f k ohm" ,(Rlmin/1E-3),(Rlmax/1E+3))
printf ( " Il = %.e A",Il)
printf ("max power consumed is %.f mW",P)
```

Scilab code Exa 1.27 Example

```
//Variable declaration
Vz=20                //zener voltage(V)
Izmax=50             //maximum zener current(mA)
Rz=0                 //zener resistance(ohms)
Rl=2.                //load resistance(ohm)
Vl=20.               //as Vz=Vl(V)
Rs=0.25              //source resistance(k ohms)

//Calculations
//Part a
Il=Vl/Rl                //load current(mA)
Vsmin=(Rs+Rl)*Il        //as Iz is floating so Iz=0

//Part b
Is=Izmax+Il             //source current(mA)
Vsmax=Vz+(Is*Rs)        //maximum source voltage(V)

//Results
printf ("Vsmin %.1f V",Vsmin)
printf ("Range of input voltage is %.1f to %.1f V",
   Vsmin, Vsmax)
```

Scilab code Exa 1.28 Example

```
//Variable declaration
Ilmax=100                   //load maximum current(mA)
Ilmin=0                     //load minimum current(mA)
Rz=0.05                     //zener diode resistance(
   ohms)
```

```
Rs=10.                     //source resistance(k ohms
    )
Vl=16.015                  //load voltage(V)
Vl1=16.                    //nominal load voltage(V)
Vs=20                      //source voltage(V)
Vz=16                      //zener diode voltage(V)

//Calculations
//Case 1 (i)
Iz=(Vl-Vl1)/Rz             //zener current(mA)
Is=Iz+Ilmax                //supply current(A)

//Case 1 (ii)
Is1=(Vs-Vz)/(Rs+Rz)             //supply current(mA)
Vl2=Vl1+(Is1*Rz)                //voltage(V)
Vr=((Vl2-Vl)/Vl1)*100          //voltage regulation

//Case 2 (i)
Vs=18                          //supply voltage(V)
Ilmax=0.1                      //load current max(A)
Vl=16.005                      //load voltage(V)
Iz=(Vl-Vl1)/Rz                 //zener current(mA)
Is2=Ilmax+Iz                   //supply current(A)

//Case 2 (ii)
Ilmin=0
Iz1=(Vs-Vl1)/(Rs+Rz)          //minimum diode current(
    mA)
Vl=Vl1+(Iz*Rz)                //load voltage at Ilmin(
    V)

//Part a
//Variable declaration
Is=0.4                    //supply current(A)
Vs=20                      //supply voltage(V)
Vl=16.015                 //load voltage(V)
Iz=0.3                     //zener current(mA)

```

```
//Calculations
P=Is**2*Rs                    //power dissipated by Rs(W)

//Part b
Pd=Vl*Iz                      //power dissipated(W)
Po=(Vs**2)/Rs                 //output power(W)

printf ("maximum power dissipated by Rs is %.1f W",P)
printf ("maximum power dissipated by diode is %.3f W",Pd)
printf ("minimum diode current is %.3f A",Iz1)
printf ("voltage regulation is %.2f %%",Vr)
printf ("output shorted will be %.1f W",Po)
```

Scilab code Exa 1.29 Example

```


//Variable declaration
Vrms=20                       //secondary voltage(V)
Rs=10                         //Winding resistance(ohm)
Rf=5                          //diode has forward resistance(ohms)
Idc=2*10**-3                  //load current(mA)

//Calculations
//Part a
Vdc=(Vrms*(sqrt(2)))/(%pi)          //no load Vdc

//Part b
Vldc=Vdc-(Idc*(Rs+Rf))                          //dc output voltage when load is 20mA

//Part c
```

```
Rl=Vldc/Idc                                         //load resistance(ohms)
r=((Rs+Rf)/Rl)*100                                  //percentage regulation(%)

//Part d
Im=Idc*(%pi)                                    //peak current(mA)
Ilrms=Im/2                                          //rms load current(mA)
Vlrms=Ilrms*Rl                                      //rms load voltage(V)
Vlrmsac=sqrt((Vlrms**2)-(Vldc**2))      //Ripple voltage rms(V)
f=50*2                                              //rippLe frequency(Hz)

//Part e
eta=(((2*(%pi))**2)/(1+((Rs+Rf)/Rl)))*100   //efficiency

//Part f
PIV=Vrms*(sqrt(2))                              //peak inverse voltage(V)
Vm= PIV
//Results
printf ("no load dc voltage is %.f V",Vdc)
printf ("dc output voltage when the load is drawing 20 mA is %.2f V",Vldc)
printf ("percentage regulation at this load is %.2f %%",(r/1E-1))
printf ("ripple voltage rms is %.2f V and ripple frequency is %.f Hz",Vlrmsac,f)
printf ("power conversion efficiency is %.1f %%",(eta/1E+2))
printf ("PIV is %.f V",PIV)
```

Scilab code Exa 1.30 Example

```


//Variable declaration
Vl=24                          //battery voltage(V)
Vm=60*(sqrt(2))           //peak voltage(V)
Ip=2.5                          //peak current(A)
c=20                            //charge(Ah)

//Calculations
//Part a
theta=asin(Vl/Vm)         //angle at which conduction
    begins
Rs=(Vm-Vl)/Ip                 //source resistance(ohms)

//Part b
Idc=(Vm/(%pi)*Rs)*(cos(theta))-(((%pi)-(2*theta))/2*
    %pi)*(Vl/Rs)    //load current(A)
T=c/Idc

    //time to deliver 20Ah(h)

//Results
printf ("resistance connected in series is %.1f ohm"
    ,Rs)
printf ("time required to deliver a charge of 20 Ah
    is %.1f h",(T/1E-3))
printf ("Idc %.2f A",(Idc/1E+3))
```

Scilab code Exa 1.32 Example

```
//Variable declaration
R=25.                       //external resistance(ohms)
Vm=200.                     //peak value of voltage(V) as vs=200 sinwt
Rf=50.                      //forward resistance(ohms)

//Calculations
//Part a
Id=Vm/(2*Rf+R)            //diode current(peak)

//Part b
Idc=(2*Id)/%pi        //dc current(A)

//Part c
PIV=Vm/2                      //peak value of voltage across D1
PIVac=100/%pi          //average value of voltage across D1

//Part d
Im=Id                         //peak value of current(A)
Irms=Im/(sqrt(2)) //rms value of current(A)

//Results
printf ("peak value of current is %.1f A",Id)
printf ("dc currect is %.2f A",Idc)
printf ("across D1 are peak voltage is %.1f V and average voltage is %.1f V",PIV,PIVac)
printf ("Irms is %.2f A",Irms)
```

Scilab code Exa 1.33 Example

```

//Variable declaration
f=50.                  //frequency(Hz)
dv=7.                  //difference between maximum and
    minimum(25-18)voltages across the load(V)
Ic=100.                //load current(mA)

//Calculations
dt=1/(2*f)            //time of discharge(seconds)
C=Ic/(dv/dt)          //capacitance(uF)

//Results
printf ("value of capacitor is %.2f uF",(C/1E-3))
```

Scilab code Exa 1.34 Example

```


//Variable declaration
Vr=10.                               //peak to peak
    ripple voltage(V)
Vm=50.                               //peak output
    voltage(V)
C=300.                               //Capacitance(uF)
Rl=470.                              //load resistance(
    ohms)
f=50.                                //frequency(Hz)

//Calculations
//Part a
Vdc=Vm-(Vr/2)                        //dc voltage(V)
C=Vdc/(f*Vr*Rl)                      //capacitance(mF)

//Part b
C1=300*10**-6                         //capacitance is
```

```
    increased(uF)
Vr=2*Vm/((2*f*C1*Rl)+1)
Vdc=Vm-Vr/2                         //load voltage
    ripple(V)
Idc=Vdc/Rl                          //average load
    current(mA)

//Results
printf ("value of capacitor is %.1f mF",(C/1E-6))
printf ("load voltage ripple is %.2f V and average
    load current is %.1f mA",Vdc,(Idc/1E-4))
```

Scilab code Exa 1.35 Example

```


//Variable declaration
vo=7.5                    //instantaneous voltage(V)
R1=15                     //resistance(k ohms)
Von=0.5                   //voltage of diode when on(V
    )

//Calculations
Rth=(R1*vo)/(R1+vo)                    //equivalent
    resistance(V)
T=2*(%pi)/10**4                     //time period(ms)
t1=(asin(Von/2.5))/10**4          //timimgs when D1
    conducts(ms)
t2=(T/2)-t1

//Results
printf ("time period is %.3f ms",(T/1E-3))
printf ("t1 is %.3e ms",t1)
printf ( "t2 is %.3f ms",(t2/1E-3))
```

Scilab code Exa 1.36 Example

```


//Variable declarations
v=12                              //output voltage(V)
vm=20.                            //peak voltage(V)
v1=8                              //output voltage(V) for negative half cycle
vm1=20.                           //peak voltage(V) for negative half cycle

//Calculations
t1=(asin(v/vm))/10**4              //for positive half cycle when D1 conducts
t2=(0.1*%pi)-t1/1e-3
t3=(asin(v1/vm1))/10**4            //for negative half cycle when D2 conducts
t4=(0.1*(%pi))+t3/1e-3
t5=(0.2*(%pi))-t3/1e-3

//Results
printf("t1 is %.3f ms",t1/1e-3)
printf("t2 is %.2f ms",t2)
printf("t3 is %.3f ms",t3/1e-3)
printf("t4 is %.3f ms",t4)
printf("t5 is %.3f ms",t5)
printf("vo is -5.33+6.66*sin(10**4*.15)")
```

Chapter 2

TRANSISTORS AND OTHER DEVICES

Scilab code Exa 2.1 Example

```
//Variable declaration
Rb=200                      //base resistance(ohm)
Vbe=0.7                     //base emitter voltage drop(V) in active region
Vbb=5                       //base voltage of bipolar transistor(V)
beeta=100                   //current gain
Rc=3                        //collector resistance(k ohms)
Vcc=10                      //voltage given to the collector(V)

//Calculations
Ib=(Vbb-Vbe)/Rb               //base current(mA)
Ic=beeta*Ib                   //collector current(mA)
Vcb=-Vbe-(Rc*Ic)+Vcc          //collector base voltage drop(V)

//Results
```

```
printf ("Base current  Ib = %.4f mA",Ib)
printf ("Collector current Ic = %.2f mA",Ic)
printf ("Reverse bias collector junction Vcb =  %.2f V",Vcb)
```

Scilab code Exa 2.2 Example

```
//Variable declaration
Vbb=5                //base voltage of bipolar transistor(V)
Vbe=0.7              //base emitter voltage drop(V) in active region
Rb=150               //base resistance(ohm)
beeta=125            //curret gain
Rc=3                 //collector resistance(k ohms)
Vcc=10               //supply voltage(V)
Vce=0.2              //collector to emitter voltage(V)

//Calculations
//Part a
Ib=(Vbb-Vbe)/Rb        //base current(mA)
Ic=beeta*Ib            //collector current(mA)
Vcb=-Vbe-(Rc*Ic)+Vcc   //collector base voltage drop(V)

//Part b -for npn transistor
Vbe=0.8              //base emitter voltage drop(V) in saturation
Ic=(Vcc-Vce)/Rc      //collector current(mA)
Ib=(Vbb-Vbe)/Rb      //base current(mA)
Ibmin=Ic/beeta       //minimum base current(mA) to go into saturation(mA)

//Results
```

```
printf ("In active region , base current is %.1e mA
    and collector current is %.2f mA" ,Ib,Ic)
printf ("base current and collector current in npn
    are %.2e mA and %.2f mA resp.",Ib,Ic)
printf ("base current minimum is %.3f mA",Ibmin)
```

Scilab code Exa 2.3 Example

```
//Variable declaration
Vbb=5                      //base voltage of bipolar
    transistor(V)
Vbe=0.7                    //base emitter voltage drop(V)
     in active region
Rb=50                      //base resistance(ohm)
beeta=50                   //current gain
Re=1.8                     //emitter resistance(k ohms)
Vcc=10                     //supply voltage(V)
Vce=0.2                    //collector to emitter voltage
    (V)

//Calculations
Ib=(Vbb-Vbe)/(Rb+Re*(beeta+1))          //base current(
   mA)
Ic=beeta*Ib                             //collector
    current(mA)
Ie=Ib+Ic                                //emitter
    current(mA)

//Results
printf ("values are Ib: %.2f mA, Ic: %.2f mA and Ie
    : %.2f mA",Ib,Ic,Ie)
```

Scilab code Exa 2.4 Example

```
//Variable declaration
Vbe=0.7                          //base to emitter
   voltage(V)
Rb=250                           //base resistance(k
   ohms)
Vcc=10                           //supply voltage(V)
Rl=0.5                           //load resistance(k
   ohms)

//Calculations
Ic=Vcc/Rl                        //collector current(mA)
IbQ=(Vcc-Vbe)/Rb                 //Ib at operating point
   (uA)
IcQ=8                            //Ic at operating point
   (mA)
VceQ=6                           //Vce at operating
   point(V)

//Results
printf("values are IbQ : %.4f uA,IcQ: %.f mA and
   Vcc : %.f V",IbQ,IcQ,Vcc)
printf("collector current Ic is %d mA and output
   voltage,vL=6-2 sinwt V",Ic)
```

Scilab code Exa 2.5 Example

```
//Variable declaration
Vgs=12                       //gate to source voltage(V)
Vt=4                         //threshold voltage(V)
Id=12.8                      //drain current(mA)
K=0.0002                     //device parameter
Vdd=24                       //drain voltage(V)
Vds=8                   //drain to source voltage(V)
Vgs=8

```

```
//Calculations
Id=K*((Vds-Vt)^2)          //drain current at Vds=8V
Rd=(Vdd-Vds)/Id             //drain resistance(k ohms)

//Result
printf ("diode resistance is %.f ohms",Rd)
```

Scilab code Exa 2.7 Example

```
//Variable declaration
Vds=7.5                     //drain to source voltage(V)
Id=5                        //drain current(mA)

//Calculations
Vgs=-1.5                    //gate to source voltage(V)
Vgg=-Vgs                    //gate voltage=gate to source
    voltage(V)

//Result
printf ("gate voltage is %.1f V",Vgg)
```

Scilab code Exa 2.8 Example

```
//Variable declaration
Vds=7.5                       //drain to source voltage(V
   )
Idss=8.                       //drain current for Vgs(V)
Vgs=2.                        //gate to source voltage(V)
Vp=4.                         //peak voltage(V)

//Calculations
Id=Idss*((Vp-Vgs)/Vp)**2    //drain current(mA)

```

```
//Result
printf ("diode current is %.1f mA",Id)
```

Scilab code Exa 2.10 Example

```
//Variable declaration
beeta=160                  //current gain
Vee=10                     //emitter voltage(V)
Rb=400                     //base resistance(k ohms)
Veb=0.8                    //emitter to base voltage(V)
Re=2.5                     //emitter resistance(k ohms)
Rc=1.5                     //collector resistance(k
   ohms)

//Calculations
//Part a
Ib=(Vee-Veb)/((Re*(1+beeta))+Rb)     //base current(
   uA)
Ic=beeta*Ib                          //collector
   current(mA)
Ie=(beeta+1)*Ib                      //emitter
   current(mA)
Vce=Vee-(Re*Ie)-(Rc*Ic)              //emitter to
   collector voltage(V)
Vce=-Vce                             //collector to
   emitter voltage(V)

//Part b
beeta=80                             //current gain
Ib1=(Vee-Veb)/((Re*(1+beeta))+Rb)    //base current(
   uA)
Ic1=beeta*Ib1                        //collector
   current(mA)
Ie1=(beeta+1)*Ib1                    //emitter
   current(mA)
```

```
Vce1=-(Vee-(Ie1*Re)-(Rc*Ic1))         //collector to emitter voltage(V)

//Result
printf ("collector current and Vce for beeta=160 are %.2f mA and %.2f" ,Ic,Vce)
printf ("Ic and Vce for beeta=80 are %.2f mA and %.2f",Ic,Vce1)
```

Scilab code Exa 2.13 Example

```

//Variable declaration
K=2                            //device parameter
Rd=2.5*10**3               //drain resistance(k ohms)
Rs= Rd
R1=100*10**3                   //resistance(ohms)
R2=200*10**3                   //resistance(ohms)
Vdd=12                         //drain voltage(V)
Vt=4                           //threshold voltage(V)

//Calculations
Vgg=(R2*Vdd)/(R1+R2)
syms Id
expr=solve([Id**2-3.28*Id+2.56],[Id])
disp(expr)
Id=1.28
Vds=Vdd-5*Id

//Result
printf ("Id is %.2f mA and Vds is %.1f V",Id,Vds)
```

Scilab code Exa 2.14 Example

```
//Variable declaration
k=2.                          //device parameter
Vt=-1.                        //threshold voltage(V)
Vdd=-12.                      //drain voltage(V)
R1=300.                       //resistance(kohms)
R2=100.                       //resistance(kohms)

//Calculations
//Part a
Vgs=-2                     //gate to source voltage(V)
Vgg=(R2*Vdd)/(R1+R2)       //gate voltage(V)
Id=k*((Vgs-Vt)**2)         //drain current(mA)
Rs=(Vgs-Vgg)/Id            //source resistance(k ohms)
   as Id=Is,Kvl in GS loop
Is=Id

//Part b
Vds=-4                        //drain to source voltage(
   V)
Rd=(-Vdd+Vds-(Is*Rs))/Id  //applying kvl in DS loop

//Part c
Vt=-1.5                          //threshold voltage(V)
Vgg=-1.5                         //gate voltage using Id
    formula
R2new=(Vgg*R1)/(Vdd-Vgg)         //new resistance(k ohms
   )

//Results
printf ("a)source resistance is %.1f kohm",Rs)
printf ("b)drain resistance is %.1f kohm",Rd)
printf ("c)R2new is %.2f kohm",R2new)
```

Scilab code Exa 2.15 Example

```
//Variable declaration
Vp=-4                          //peak voltage(V)
Idss=10                        //drain current for Vgs(V)
Vdd=18                         //drain voltage(V)
Rs=2                     //source resistance(ohms)
Rd=2                     //drain resistance(ohms)
R1=450*10**3                   //resistance(ohms)
R2=90*10**3                    //resistance(ohms)

//Calculations
Vgg=(R2*Vdd)/(R1+R2)
syms Id
expr=solve([20*Id**2-148*Id+245],[Id])
disp (expr)
Id1=2.5
Vds=Vdd-((Rs+Rd)*Id1)

//Result
printf ("Id is %.1f mA and Vds is %.1f V",Id1,Vds)
```

Scilab code Exa 2.16 Example

```
//Variable declaration
Vp=4                          //peak voltage(V)
Idss=12.                      //drain current for Vgs(V)
Vdd=12                        //drain voltage(V)
Id=4.                         //drain current(mA)
Vds=6                         //drain to source voltage(V)

//Calculations
Rs=(Vp/4)*(1-(sqrt(Id/Idss)))        //by Id=Idss(1-(
```

```
    Vgs/Vp))^2 and putting Vgs=4Rs in it and solving
Rd=((Vdd+Vds)/Id)-Rs                              //solving
    equation -Vdd-Vds+(Id*(Rd+Rs))=0

//Result
printf ("source resistance is %.2f kohm",Rs)
printf ("drain resistance %.2f kohms",Rd)
```

Chapter 3

SMALL SIGNAL MODELS AMPLIFICATION AND BIASING

Scilab code Exa 3.1 Example

```
//Variable declaration
beeta=100              //current gain
Ic=2.5                 //collector current(mA)
Io=-0.5                //output current(mA)
Rl=2.5                 //load resistance(kohm)

//Calculations
rpi=beeta*(25/Ic)     //dynamic resistance(ohms)
Ib=Io/(-beeta)        //as Io=-beeta*Ib
Vs=rpi*Ib             //signal voltage(V)
Vo=Rl*Io              //output voltage(V)
Av=Vo/Vs              //voltage gain
Ai=Io/Ib              //current gain

//Results
printf ("signal voltage is %.1f mV",Vs)
printf ("current gain is %.1f",Ai)
```

```
printf ("voltage gain is %.f",Av/1E-3)
```

Scilab code Exa 3.2 Example

```


//Variable declaration
Id=1.6                    //drain current(mA)
Vgs=-3                    //gate to source voltage(V)
Id1=.4                    //drain current(mA)
Vgs1=-4                   //gate to source voltage(V)
Vp=-5                     //peak voltage(V) by solving equations 1.6=Idss(1+3/Vp)^2 and .4=Idss(1+4/Vp)^2
Idss=10                   //small signal drain current(mA) by solving equations 1.6=Idss(1+3/Vp)^2 and .4=Idss(1+4/Vp)^2

//Calculations
gmo=-(2*Idss)/Vp                    //transconductance(mS)
gm=gmo*(sqrt(Id/Idss))      //transconductance(uS)
gm1=gmo*(sqrt(Id1/Idss))    //transconductance(uS)

//Results
printf ("Idss and Vp are %.f mA and %.f V",Idss,Vp)
printf ("gmo is %.f mS",gmo)
printf ("gm at Id is %.f  gm at Id1 is %.f uS",gm/1E-3,gm1/1E-3)
```

Scilab code Exa 3.3 Example

```
//Variable declaration
```

```
gm=1600                  //gm(us)
rd=50                    //resistance(kohms)
Rl=5                     //load resistance(kohms)

//Calculations
Av=-gm*Rl                //Vgs=Vs from circuit model
                         //Vo=-(gm*Vgs)*Rl
                         //as Av=Vo/Vs=-gm*Rl

//Result
printf ("voltage gain of the circuit is %.f",Av/1E
   +3)
```

Scilab code Exa 3.4 Example

```
//Variable declaration
beta=100.          //current gain
rpi=2*10**3        //dynamic resistance(ohms)
rx=500             //resistance(ohms)
ro=250*10**3       //output resistance(ohms)
R1=50*10**3        //resistance(k ohms)
R2=10*10**3        //resistance(k ohms)
Rc=5*10**3         //collector current(k ohms)
Rl=5*10**3.        //load current(k ohms)
Rs=1*10**3         //source resistance(k ohms)

//Calculations
Rb=(R1*R2)/(R1+R2)                 //equivalent
   resistance of R1 and R2(kohms)
r=rpi+rx                           //series resistance
    of rpi and rx(k ohms)
gm=beta/rpi                        //transconductance(
   mS)
Vo=-gm*((Rc*Rl)/(Rc+Rl))*.526      //output voltage(V)
    as
```

```
Av=Vo                                   //voltage gain
Ai=Av*((Rs+((Rb*r)/(Rb+r)))/Rl)   //current gain

//Results
printf ("source to load voltage gain is %.2f",Av)
printf ("source to load current gain is %f",Ai)
disp ("Note : Solution given in the textbook is incorrect")
```

Scilab code Exa 3.5 Example

```
//Variable declaration
beta=100.          //current gain
rd=50*10**3        //internal dynamic resistance(ohms
gm=5*10**-3        //transconductance(mS)
R1=50*10**3        //resistance(ohms)
R2=10*10**3         //resistance(ohms)
Rs=10*10**3         //source current(ohms)
Rg=1*10**6.         //gate resistance(ohms)
Rd=10*10**3         //drain resistance(ohms)

//Calculations
Vgs=(Rg/(Rs+Rg))                         //gate to source voltage (V) as Vgs=Vs((Rg/(Rs+Rg))
Av=-Vgs*gm*((rd*Rd)/(rd+Rd))          //voltage gain,Av=Vo/Vs and Vo=-gmVgs(rd||Rd)
Ai=Av*((Rs+Rg)/Rd)                       //current gain

//Results
printf ("source to load voltage gain is %.f",Av)
printf ("source to load current gain is %.f",Ai)
```

Scilab code Exa 3.6 Example

```
//Variable declaration
Rs=500              //collector current(k ohms)
Io=-1*10**-3        //output current(mA)
Rc=5*10**3.          //collector resistance(ohms)
hie=2*10**3
hoe=10*10**-6.
hfe=100.
hre=5*10**-4
Rb=50*10**3.        //base resistance(ohms)

//Calculations
Io1=-1/(1+Rc*hoe)*hfe    //as Io=-1/(1+Rc*hoe)*hfe*Ib
Ib=-1/Io1                //base current(uA)
Vo=Io*Rc                 //output voltage(V)
Vi=hie*Ib+Vo*hre         //input voltage(V)
Is=Ib+Vi/Rb              //source current(ohms)
Ai=Io/Is                 //current gain
Vs=(Is*Rs)+Vi            //source voltage(V)
Av=Vo/Vs                 //voltage gain

//Results
printf ("source to load voltage gain is %.f",Av/1E
    -3)
printf ("source to load current gain is %.f",Ai/1E
    -3)
```

Scilab code Exa 3.7 Example

```
//Variable declaration
beeta=100.       //current gain
Ic=4.            //collector current(mA)
Vbe=0.7          //base to emitter voltage(V)
Re=2.            //emitter resistance(ohms)
Vcc=32.          //supply voltage(V)
abeeta=40.       //actual current gain
```

```
//Calculations
Ib=Ic/beeta                          //base current(mA)
Rb=(Vcc-Vbe-((Ib+Ic)*Re))/Ib         //as Vcc=(Ib*Rb)+Vbe+(Ib+Ic)*Re
Ib=(Vcc-Vbe-8)/(Rb+Re)               //as Vcc=Rb*Ib+Vbe+(Ib+Ic)*Re
Ic1=abeeta*Ib                        //collector current(mA)
deltaIc=Ic-Ic1                       //change in collector current(mA)

//Result
printf ("change in Ic when beeta=40 is %.1f mA",deltaIc)
```

Scilab code Exa 3.8 Example

```
//Variable declaration
Rb1=36                   //base resistance 1(kohms)
Rb2=12                   //base resistance 2(kohms)
Rc=4                     //emitter resistancce(kohms)
Re=1.8                   //emitter resistance(kohms)
Vcc=12                   //supply voltage(V)
Vbe=0.7                  //base to emitter voltage(V)

//Calculations
Rb=(Rb1*Rb2)/(Rb1+Rb2)   //base resistance(ohms)
Vbb=Vcc*(Rb2/(Rb1+Rb2))  //voltage supply to base(V)
                         //(10.8*Ib)+(1.8*Ic)=2.3 equation 1...solving -Vbb+RbIb+Vbe+(Ib+IC)Re
```

```
                              //(1.8*Ib)+(5.8*Ic)+Vce=12 equation 2 solving -Vcc+RcIc+Vce+(Ob+Ic)Re
//Part a
beeta=50                      //current gain
Ib=2.3/100.8                  //(10.8*Ib)+(90*Ib)=2.3 ,using -Vbb+Rb*Ib+Vbe+(Ib+Ic)*Re
                              //as Ic=50Ib and putting this in equation 1
Icq=Ib*beeta
Vceq=Vcc-(1.8*Ib)-(5.8*Icq) //from equation 2

//Part b
beeta=150                   //current gain
Ib=2.3/280.8                // (10.8*Ib)+(270*Ib)=2.3,using -Vcc+Rc*Ic+Vce+(Ib+Ic)*Re
                            //as Ic=150Ib and putting this in equation 1
Icq1=Ib*beeta
Vceq1=Vcc-(1.8*Ib)-(5.8*Icq1)           //from equation 2

//Results
printf ("when beeta increases by 300%%,Icq increases by %.1f %%",(Icq1-Icq)/Icq1*100)
printf ("when beeta increases by 300%%, Vceq increases by %.f %%",(Vceq-Vceq1)/Vceq*100)
```

Scilab code Exa 3.9 Example

```
//Variable declaration
Ic=4                              //collector current(mA)
Vce=8                             //collector emitter voltage(V)
beeta=100                         //current gain
```

```
Rb2=24                    //base resistance(kohms)
Vbe=0.7                   //base to emitter voltage(
   V)
Rc=4                     //collector current(kohm)
Re=2                     //emitter resistance(kohms)
Ib=0.04                  //base current(mA)

//Calculations
//Part a
Vcc=(Ic*Rc)+Vce+Ic*Re          //from formula Vcc=
   IcRc+Vce+(Ic+Ib)Re..eq 1

//Part b
Rb1=Rb2*(Vcc-(Vbe+Ic*Re))/((Vbe+Ic*Re)+Ib)  //from
   eq 1 and also from Vbb= Vcc(Rb2/(Rb1+Rb2))
Rb=(Rb1*Rb2)/(Rb1+Rb2)                      //base
   resistance(ohms)
Vbb=(Vcc*Rb2)/(Rb1+Rb2)                     //supply
    to base(V)

//Part c
abeeta=40                                  //actual
   current gain
Ib1=((Vbe+Re*Ic)-Vbe)/((1+abeeta)*2+Rb)    //from
   equation Vbb=IbRb+Vbe+(Ic+Ib)Re
Ic1=abeeta*Ib1                             //
   collector gain

//Results
printf ("a)Vcc is %.1f V",Vcc)
printf ("b)values are Rb1: %.2f KOhms,Rb : %.2f kohm
    and Vbb : %.2f V" ,Rb1,Rb,Vbb)
printf ("c)actual value of Ic1 : %.2f mA",Ic1)
```

Scilab code Exa 3.10 Example

```
//Variable declaration
Vcc=10          //supply voltage(V)
Rc=4.7          //collector current(kohms)
Rb=250          //base resistance(kohms)
Re=1.2          //emitter resistance(kohms)
beeta=100       //current gain
Vbe=0.7         //base to emitter voltage(V)

//Calculations
//Part a
Ib=(Vcc-Vbe)/(Rb+(beeta*(Rc+Re)))    //base current(uA)
Ic=beeta*Ib                          //collector current(mA)
Vce=Vcc-Ic*(Rc+Re)                   //collector to emitter voltage(V)
//Part b
beeta1=150                           //current gain
Ib1=(Vcc-Vbe)/(Rb+(beeta1*(Rc+Re)))  //base current(mA)
Ic1=beeta1*Ib1                       //collector current(mA)
Vce1=Vcc-Ic1*(Rc+Re)                 //collector to emitter voltage(V)
deltaIc=((Ic1-Ic)/Ic)*100            //small change in Ic(mA)
deltaVce=((Vce-Vce1)/Vce)*100        //small change in Vce(V)

//Results
printf ("values of Ic is %.2f mA and Vce : %.2f V",Ic,Vce)
printf ("values of Ic1 is %.2f mA and Vce1 is %.2f V",Ic1,Vce1)
printf ("%% change in Ic is %.2f %% and in Vce is %.2f %% ",deltaIc,deltaVce)
```

Scilab code Exa 3.11 Example

```
//Variable declaration
Id=3                 //drain current(mA)
Vds=12               //drain source voltage(V)
Vgs=-3               //gate source voltage(V)
Vdd=36               //drain voltage(V)
Vgg=12               //gate voltage(V)
Rg=12                //gate resistance(Mohms)

//Calculations
R1=(Rg*Vdd)/Vgg               //resistance(Mohms)
R2=(Rg*R1)/(R1-Rg)            //resistance(kohms)
Rs=(Vgg-Vgs)/Id               //resistance(kohms)
Rd=(Vdd-Vds-Id*Rs)/Id         //as Vdd-IdRd-Vds-IdRs
Vgs=-3.6                      //consider Vgs increases by 20%
Idnew=(Vgg-Vgs)/Rs            //new drain current(mA)

//Results
printf ("value of R1 : %.f MOhm , R2: %.f Mohms, Rs : %.f KOhm and Rd: %.f kohms",R1,R2,Rs,Rd)
printf ("new Id is %.2f mA",Idnew)
```

Scilab code Exa 3.12 Example

```

//Variable declaration
k=0.0002                      //device parameter
Vt=4                          //thevinin voltage(V)
Vdd=24                        //drain voltage(V)
Id0=3                          //drain current(mA)
```

```

//Calculations
Vgs=(sqrt(Id0/k))+4    //as Id=k(Vgs-Vt)^2
Rd=-(Vgs-Vdd)/Id0          //as Vds=Vdd-IdRd and Vgs=Vds=7.87
k=0.0003                   //device parameter

syms Id
expr = solve([Id**2-7.5*Id+13.7],[Id])
printf ("equation has 2 solutions")
disp(expr)                                    //putting value of k=0.0003 in eq of Id,
Id1=3.15                                      // we get Vgs=Vds=24-5.4Id and putting Vgs again in Id we get,
                                          // Id^2-7.5Id+13.7=0

Idchange=((Id1-Id0)/Id0)*100
    //changed Id(mA)

//Result
printf ("change in Id is %.1f %% increase",Idchange)
```

Scilab code Exa 3.13 Example

```
//Variable declaration
Vt=2                          //threshold voltage(V)
Id=8                          //drain current(mA)
Vgs=6.                         //gate to source voltage(V)
k=0.5                         //device parameter
Vdd=24                        //drain voltage(V)
Vds=10                         //drain to source
```

```
voltage(V)

//Calculations
//Part a
Vgs1=4                                          //gate to source voltage(V)
Id1=k*(Vgs1-Vt)**2                              //drain current(mA)

//Part b
Vgg=3*Vgs1                                      //gate voltage(V)
R2=(Vdd/Vgg)-1                                  //resistance(Mohms)
Rs=(Vgg-Vgs1)/2                                 //source resistance(k ohms)
Rd=(Vdd-Vds-Id1*Rs)/2

//part c
K=1.5*k                    //increased by 50%
Vgs2=3.67                  //solving 12=Vgs+4Id and Id=0.75(Vgs-2)^2
Id2=2.08                    //drain current when k is increased(mA)
Vds1=Vdd-Id2*(Rd+Rs)       //drain to source voltage(V)

//Results
printf ("drain current defined by Vgs=4 and Vds=10 is %.1f mA",Id1)
printf ("value of Rs,Rd,R2 are %.1f k ohms %.1f k ohms %.1f Mohms resp.",Rs,Rd,R2)
printf ("actual value of Id and Vds are %.2f mA %.2f mA and %.2f V resp.",Id2,Vds1,Vds)
```

Scilab code Exa 3.14 Example

```
//Variable declaration
Ic=10                           //collector current(mA)
beeta=100                       //current gain
Vbe=0.7                         //base to emitter voltage(V)
Vcc=10                          //supply voltage(V)

//Calculations
//Part a
R=(beeta*(Vcc-Vbe))/((beeta+2)*Ic)            //resistance(k ohms)
beeta1=200                                    //current gain
Ic1=(beeta1/(beeta1+2))*((Vcc-Vbe)/R)         //collector current(mA)
Icchange=((Ic-Ic1)/Ic)                        //change in collector current(mA)

//Part b
Ic2=0.1                                       //collector current(mA)
R1=(beeta*(Vcc-Vbe))/((beeta+2)*Ic)           //resistance(k ohms)
Ic3=(beeta1/(beeta1+2))*((Vcc-Vbe)/R1)        //collector current(mA)
Icchange1=((Ic2-Ic3)/Ic2)                     //change in collector current(mA)

//Results
printf ("%% change in Ic is %.1f %% increase",Icchange)
printf ("%% change in Ic is %.1f %% increase",Icchange1)
```

Scilab code Exa 3.15 Example

```
//Variable declaration
Vcc=6                          //supply voltage(V)
R=1.2                          //resistance(k ohms)
Vbe=0.7                        //base to emitter voltage(V)
beeta=100.                     //current gain

//Calculations
//Part a
Ir=(Vcc-Vbe)/R                 //current(mA)
I=(beeta/(beeta+3))*Ir         //current(mA)as transistors are identiical,I=Ie

//Result
printf ("load current I is %.2f mA ",I)
```

Scilab code Exa 3.16 Example

```


//Variable declaration
Idss=10                   //drain current for zero bias(mA)
Vp=-4                     //peak voltage(V)
Idq=2.5                //quienscent drain current(mA)
Id=Idq
Vdd=24                    //voltage drain drain(V)
Vgg=4                     //gate voltage(V)
R1=22                     //resistance(Mohms)

```

```
//Calculations
//Part a
Vgs=Vp*(1-(sqrt(Id/Idss)))          //solving Id=Idss(1-Vgs/Vp)^2
Rs=(Vgg-Vgs)/Id                     //as Vgg-Vgs-IdRs=0 ,Id=Is
Rd=2.5*Rs                           //given
R2=(Vgg*R1)/(R1-Vgg)                //from Vgg=(R1*R2)/(R1+R2)

//Part b
gmo=-(2*Idss)/Vp                    //transconductance(mS)
gm=gmo*(sqrt(Id/Idss))              //transconductance(mS)

//Part c
Av=-gm*Rd                           //voltage gain

//Results
printf ("values of Rs : %.1f Kohms, Rd : %.1f k ohms and R2 is %.1f M ohms",Rs,Rd,R2)
printf ("value of gm is %.1f mS and gmo is %.1f mS",gm,gmo)
printf ("voltage amplification is %.1f",Av)
```

Scilab code Exa 3.17 Example

```


//Variable declaration
beeta=98.                           //current gain
rpi=1.275                           //dynamic resistance(k ohms)
```

```
Rb=220.                             //base resistance(k ohms)
Re=3.3                              //emitter resistance(k ohms)
Vcc=12.                             //supply voltage(V)
Vbe=0.7                             //base to emitter voltage(V)

//Calculations
//Part a
x=rpi/(1+beeta)
Av=Re/(Re+x)                       //voltage gain

//Part b
Zb=rpi+(1+beeta)*Re               //impedance(k ohms)
Zi=(Zb*Rb)/(Zb+Rb)                //input impedance(k ohms)
Zo=(Re*x)/(Re+x)                  //output impedance(k ohms)

//Part c
Ib=(Vcc-Vbe)/(Rb+(Re*(1+beeta)))      //as Ie=(1+beeta)*Ib
Ic=beeta*Ib                          //collector current(mA)
rpi=beeta*(25/Ic)                    //dynamic resistance(k ohms)

//Results
printf ("voltage gain is %.3f",Av)
printf ("input impedance is %.1f KOhm and output impedance is %.1f ohms",Zi,Zo/1E-3)
printf ("value of Ic is %.3f mA",Ic)
printf ("value of rpi is %.3f k ohms",rpi/1E+3)
```

Scilab code Exa 3.18 Example

```


//Variable declaration
Idss=16                                    //drain current
    bias to zero(mA)
Vp=-4                                      //pinch off
    voltage(V)
Rg=1                                       //gate resistance(
    ohms)
Rs=2.2                                     //sourse
    resistance(ohm)
Vdd=9                                      //drain drain
    voltage(V)

//Calculations
//Part a
//Id=Idss*(1-(Vgs/Vp))**2
// putting value of Vgs=2.2*Id inequation of Id,we
    get
//Id**2-3.84Id+3.31

syms Id
expr=solve([Id**2-3.84*Id+3.31],[Id])
disp(expr)
Id1=1.3
Vgs=-Id1*Rs
    //gate to source voltage(V)
gm0=-(2*Idss)/Vp
    //transconductance(mS)
gm=gm0*(1-(Vgs/Vp))
    //transconductance(mS)
rm=1/gm
```

```
//transresistance(k ohms)
Av=(Rs*gm)/(1+(Rs*gm))
//voltage gain

//Part b
Zi=Rg
//input impedance(Mohms)
Zo=(Rs*rm)/(Rs+rm)
//output impedance(ohms)

//Results
printf ("voltage gain is %.3f",Av)
printf ("input and output impedences are %.f Mohms and %.1f ohms",Zi,Zo/1E-3)
```

Scilab code Exa 3.19 Example

```


//Variable declaration
Re=0.56                          //emitter resistance(k ohms)
beta=1600                        //current gain
R1=110                           //resistance(k ohms)
R2=330                           //resistance(k ohms)

//Calculations
//Part a
Av1=Re*(beta+1)                //voltage gain

//part b
Rb=(R1*R2)/(R1+R2)              //base resistance(k ohms)
```

```
Vs=(1.56/(Re*(beta+1)))+1         //source voltage(V)
Avs=1/Vs

//part c
R=1+(1+beta)*Re    //resistance presented to Ib
I=Rb/(Rb+R)    //I=Ib/Ii
Ai=(1+beta)*I    //current gain

//part d
Rl=10*10**3                                    //load resistance(ohm)
Re1=(Re*Rl)/(Re+Rl)                            //emitter resistance(k ohms)
R1=1+(1+beta)*Re1                              //resistance presented to Ib(k ohms)
I1=Rb/(Rb+R1)                                  //I1=Ib/Ii
Ai1=(beta+1)*I1                                //current gain
Av2=Re1*(1+beta)                               //voltage gain

//Results
printf ("a)voltage gain is %.2f",Av1)
printf ("b)Avs is %.2f",Avs)
printf ("c)Ai is %.2f ",Ai)
printf ("when output Vo1 feeds a load of 10 k ohms Ai is %d and Av2 is %.f",Ai1,Av2)
```

Scilab code Exa 3.20 Example

```
//Variable declaration
beeta1=120.                        //current gain
```

```
beeta2=160.                        //current gain
Vcc=18                             //supply voltage(V)
Rc=0.1                             //collector resistance(ohms)
Rb=2*10**3.                        //base resistance(ohms)
Vbe=0.7                            //base to emitter voltage(V)

//Calculations
Ib1=(Vcc-Vbe)/(Rb+(beeta1*beeta2*Rc))//base current(uA)
Ib2=beeta1*Ib1                     //base current(mA)
Ie1=(beeta1+1)*Ib1                 //emitter current(mA)
Ic=Ie1+(beeta2*Ib2)                //collector current(mA)
Vo=Vcc-(Ic*Rc)                     //output voltage(V)
Vi=Vo-Vbe                          //input voltage(V)

//Results
printf ("dc biased current is %.1f mA",Ic)
printf ("output voltage %.2f V",Vo)
printf ("input voltage %.2f V",Vi)
```

Scilab code Exa 3.21 Example

```


//Variable declaration
deltaId=2.                         //change in Id(mA)
```

```
deltaVgs=1.                          //change in Vgs(V)
deltaVds=5.                          //change in Vds(V)
Idss=10.                             //drain current biased to zero(mA)
Id=5.                                //drain current(mA)
Vp=-6.                               //pinch off voltage(V)

//Calculations
//Part a
gm=(deltaId)/(deltaVgs)              //transconductance(mS)
rds=(deltaVds)/(deltaId)             //resistance(k ohms)
gm0=-(2*Idss)/Vp                     //transconductance(mS)
gm=gm0*(sqrt(Id/Idss))           //transconductance(mS)

//Part b
R1=4.5                               //resistance(k ohms)
R2=2                                 //resistance(k ohms)
Av=gm*((R1*R2)/(R1+R2))              //voltage gain

//Results
printf ("drain current biased to zero is %.1f mA and pinch off voltage is %.1f V",Idss,Vp)
printf ("value of gm and rds are %.2f mS and %.2f k ohms",gm,rds)
printf ("small signal amplifier gain is %.2f ",Av)
```

Scilab code Exa 3.22 Example

```
//Variable declaration
Idson=0.2
Vgs=5                        //gate to source voltage(V)
Vdd=12                       //drain voltage(V)
Vt=2                         //thevinine voltage(V)
R1=100.                      //resistance(k ohms)
R2=100.                      //resistance(k ohms)
Rd=30                        //drain resistance(K ohms)
Rs=6                         //source resistance(k ohms)
deltaVdd=0.3                 //change in Vdd(V)
rds=50                       //internal drain to source resistance()

//Calculations
//Part a
k=Idson/((Vgs-Vt)**2)                //device parameter
Vgg=Vdd*(R1/(R1+R2))                 //gate voltage(V)
Vgs=4.89                             //gate to source voltage(V)
Id=k*(Vgs-Vt)**2                     //drain current(mA)
Vds=Vdd-((Rd+Rs)*Id)                 //drain to source voltage(V)
gm=2*(sqrt(k*Id))                  //transconductance(mS)
deltaVgg=deltaVdd*(R2/(R1+R2))       //change in Vgg(V)

vgs=0.105                            //as vgs=0.15-6id where id=u*vgs/(rds+Rs+Rd)=0.74vgs after solving
id= 0.074*vgs*10**3
```

```

//Results
printf ("id is %.2f uA",id)
```

Scilab code Exa 3.23 Example

```


//Variable declaration
deltaId=1                              //change in Id(mA)
deltaVgs=0.75                          //change in Vgs(V)
rd=100                                 //internal drain
    resistance(k ohms)
Rd=100                                 //drain resistance
    (k ohms)
Vgs=2                                  //as Vgs= 2sinwt

//Calculations
gm=(deltaId)/(deltaVgs)                //transconductance
    (m)
Vo=-gm*Vgs*((rd*Rd)/(rd+Rd))           // as Vi=2sin(w*t)

//Results
printf ("value of Vo is %.f *sinwt mV",Vo)
```

Scilab code Exa 3.24 Example

```
//Finding resistance

//Variable declaration
Rd=4                 //drain resistance(ohms)
Rs=2.5               //ource resistance(ohms)
R1=200*10**3         //resistance(ohms)
```

```
R2=100*10**3            //resistance(ohms)
gm=2.5                  //transconductance(mS)
rd=60                   //internal drain resistance(ohms)

//Calculations
//Part b
Ro=Rs/(1+(((1+gm*rd)*Rs)/(rd+Rd)))    //output resistance(ohms)

//Part c
Rd1=0                                //drain resistance
Ro1=Rs/(1+(((1+gm*rd)*Rs)/rd))       //output resistance(ohms)

//Results
printf ("value of Ro is %.f ohms",Ro/1E-3)
printf ("value of Ro1 is %.f ohms",Ro1/1E-3)
```

Scilab code Exa 3.25 Example

```
//Variable declaration
beeta=100                        //current gain factor
Vbe=0.7                          //base to emitter voltage(V)
Rb=250                           //base resistance(k ohms)
Vee=10                           //emitter voltage(V)
Re=1                             //emitter resistance(k ohms)

//Calculations
Ib=(Vee-Vbe)/(Rb+1+beeta)        // solving Rb*Ib+Vbe+(Ic+Ib)=Vee and putting Ic+Ib=(1+beeta)Ib
```

```
Ic=beeta*Ib                         //collector current(
    mA)
rpi=beeta*(25/Ic)                   //dynamic resistance
    (ohms)
Vi=(rpi*Ib)+(1+beeta)*Re*Ib         //input voltage(V)
Ri=Vi/Ib                            //input resistance(k
    ohms)

//Results
printf ("value of Ri is %.1f K ohms",Ri/1E+1)
```

Scilab code Exa 3.26 Example

```
//Variable declaration
beeta=125                           //current gain
gm=35                               //transconductance(
    mS)
Re=4                                //emitter resistance
    (k ohms)
Rb=1.5                              //base resistance(k
    ohms)

//Calculations
//Part a
rpi=beeta/gm                       //dynamic resistance(
    k ohms)
Ri=rpi+((1+beeta)*Re)              //input resistance(k
    ohms)
Ro=((Rb+rpi)*Re)/((Rb+rpi)+((1+beeta)*Re))   //output
    resistance(ohms) as Ro=Vo/Isc

//Part b
f=((1+beeta)*Re)/(Rb+rpi+((1+beeta)*Re))   //transfer
    function

```

```
//Results
printf ("value of Ri is %.1f K ohms and Ro is %.4f k",Ri,Ro)
printf ("transfer function is %.2f",f)
```

Scilab code Exa 3.28 Example

```
//Variable declaration
Vcc=16                    //supply voltage(V)
Vc=12                      //collector voltage(V)
Ic=8                       //collector current(mA)
Ic1=12
deltaIc=2000               //collector current(uA)
deltaVce=4                 //collector emitter voltage(Vce)
deltaIb=20                 //base current(mA)
Rl=2.                      //load reistance(k ohms)

//Calculations
hfe=(deltaIc)/(deltaIb)
hoe=(deltaIc)/(deltaVce)
Rdc=Vcc/Ic                            //dc resistance(k ohms)
Rac=Vc/Ic1                            //ac resistance(k ohms)
Re=Rdc-Rac                            //emitter resistance(k ohms)
Rac1=(Rac*Rl)/(Rac+Rl)                //for load of 2 kohms, Rc=Rac
Icq=Vcc/(Rac1+Rdc)                    //Ic at operatingpoint(mA)
Vceq=Vcc-(Icq*Rdc)                    //Vc at operating point(V)

//Results
```

```
printf ("value of hfe and hoe are %d uS and %d uS",
    hfe,hoe)
printf ("value Rc and Re are %d k ohms and %d k ohms
     resp.",Rac,Re)
printf ("value of Icq and Vce %d mA and %.1f V resp.
    ",Icq,Vceq)
```

Scilab code Exa 3.29 Example

```
//Variable declaration
hfe=120                     //current gain
r1=1.5                      //resistance(k ohms)
Vi=1                        //input voltage(V)
hoe=50*10**-3               //output conductance with input
     open circuited
Rs=2                        //source resistance(k ohms)
Vbe=0.7                     //base to emitter voltage(V)
Vcc=10                      //supply voltage(V)
r3=0.33                     //resistance(k ohms)
r4=5.8                      //rsistance(k ohms)
r5=27                       //rsistance(k ohms)
hoe=50*10**-3               //output conductance with input
     open circuited

//Calculations
//Part a
Vbb=Vcc*(r4/(r4+r5))                //voltage to bae(V)
Rb=(r5*r4)/(r5+r4)                  // as Vbb-Vbe=RbIb+(
    hfe+1)Ib*R, here hfe=beeta
ib=(Vbb-Vbe)/(Rb+(hfe+1)*r3)        //instantaneous base
    current(mA)
hie=(0.02/ib)*10**3
Ib=Vi/hie                          //base current(mA)
h=hfe*Ib
Avo=-h*r1                          //voltage gain
```

```

//Part b
r=1/hoe                     //resistance(k ohms)
R1=(r*r1)/(r+r1)            //resitance(k ohms)
R=(R1*Rs)/(R1+Rs)           //resistance(k ohms)
Ib1=1/(Rs+R)               //base current(mA)
h1=hfe*Ib1
Avl=-h1*R                  //voltage gain

//Results
printf ("hie and Avo are %.f and %.1f",hie,Avo/1E-3)
printf ("Avl is %.2f",Avl)
```

Scilab code Exa 3.30 Example

```
//Variable declaration
Rl=20                  //load resistance(ohms)
Vcc=30                 //supply voltage(V)
beeta=150              //current gain
Re=2200                //emitter resistance(ohms)
Rb=350                 //base resistance(k ohms)
Vbe=0.7                //base to emitter voltage(V)
Is=10**-3              //source current(A)
r1=2000                //resistance(ohms)

//Calculations
Ib=(Vcc-Vbe)/(Rb+(1+beeta)*Re)//base current(uA)
Ic=beeta*Ib                       //collector current(mA)
rpi=beeta*(25/Ic)                 //dynamic resistance(ohms)
R=(Re*Rl)/(Re+Rl)                 //resistance(ohms)
Ib1=17.95                         //round the base emitter(as Rb>>2 kohms,it it ignored)
Vl=(beeta+1)*Ib1*R                //load voltage(V)
```

```
Avl=Vl                                        //Voltage gain
Il=Vl/Rl                                      //load current(A
    )
Ail=Il/Is                                     //current gain

//Results
printf ("overall voltage gain is %.2f",Avl/1E+3)
printf ("overall current gain is %.f",Ail/1E+3)
```

Scilab code Exa 3.31 Example

```
//Variable declaration
Vcc=15                  //supply voltage(V)
beeta=30                //current gain
R=.47                 //emitter resistance(ohms)
Vbe=0.7                 //base to emitter voltage(V)
Vo=5                    //output voltage(V)

//Calculations
Vbb=Vcc/2                                           //base
    voltage(V)
Ib=Vo/(R*930)         //from equation(i)
R1=((6.1-4.98)/0.0114)*2                             //
    resistance(k ohms)

//Results
printf ("value of R1 is %.f K ohms",R1)
```

Chapter 4

SMALL SIGNAL AMPLIFIERS FREQUENCY RESPONSE

Scilab code Exa 4.1 Example

```


//Variable declaration
Vs = 1.                     //source voltage(V)
C = 100*10^-6              //value of capacitance(uF)
r1 = 1                      //resistance 1(k ohms)
r2 = 4                      //resistance 2(k ohms)
R = 5                       //total resistance ,R = r1+r2

//Calculations
Imax = Vs/(r1+r2)*10^3          //maximum current(uA)
fc = 1/(2*(%pi)*C*R)          //critical frequency(Hz)
                               //As w*C*R = 1 and w =
                                  2*pi*f
f = 10*fc                        //lowest frequency(Hz
    )

```

```
//Results
printf("maximum current %.1f uA",Imax)
printf("critical frequency %.3f Hz",fc/1E+3)
printf("lowest frequency %.2f Hz",f/1E+3)
```

Scilab code Exa 4.2 Example

```
//Variable declaration
C = 100*10^-6        //capacitance(uF)
Rg = 1.              //galvanometer resistance(k oms)
Rl = 4.              //load resistance(k ohms)

//Calculations
Rth = (Rg*Rl)/(Rg+Rl)        //thevinine's equivalent resistance
fc = 1/(2*(%pi)*C*Rth)   //critical frequency(Hz)
f = fc*C                     //lowest frequency(Hz)

//Results
printf("lowest frequency at which the point A gets grounded is %.1f Hz",f/1E-2)
```

Scilab code Exa 4.3 Example

```
//Variable declaration
rpi = 600                  //dynamic junction resistance(ohms)
beta = 100                 //common emitter current gain
```

```
Vs = 5.                     //source voltage(V)
Rs = 400                    //source resistance(ohms)
R = 10                      //resistance(k ohms)

//Calculations
Ib = Vs/(Rs+rpi)           //base current(uA)
Vo = R*beta*Ib            //output voltage(V)
Rin = rpi                  //input resistance(ohms)
Rout = R                   //output ewsistance(k ohms)

//Results
printf ("output voltage is %.1f V",Vo)
printf ("input resistance %.1f ohms",Rin)
printf ("output resistance %.1f k ohms",Rout)
```

Scilab code Exa 4.4 Example

```
//Variable declaration
gm = 1.                        //transconductance(mS)
rd = 40                        //dynamic drain resistance(k ohms)
Rd1 = 40                       //JFET 1 drain resistance (k ohms)
Rd2 = 10                       //JFET 2 drain resistance (k ohms)

//Calculations
Avo = (-gm*((rd*Rd1)/(rd+Rd1)))*(-gm*((rd*Rd2)/(rd+Rd2)))              //voltage gain

//Results
printf ("Avo is %.1f ",Avo)
```

Scilab code Exa 4.5 Example

```
//Variable declaration
beta = 125              //common emitter current gain
rpi = 2.5               //dynamic junction resistance(k
    ohms)
rd = 40                 //dynamic drain resistance(k
   ohms)
gm = 2                  //transconductance(mS)
Vs = 1                  //assume,source voltage(V)
Rs = 10                 //source resistance(k ohms)
Rc = 1                  //collector resistance(k ohms)
rb = 2                  //resistance(k ohms)
Vgs = 1                 //gate to source voltage(V)

//Calculations
//Part a
R = (rd*Rs)/(rd+Rs)         //equivalent resistance(k
   ohms)
Ib = gm*Vgs*(R/(rpi+R))     //base current(mA)
Vo = beta*Ib*Rc            //output voltage(V)
Avo = Vo                    //voltage gain

//Part b
Ib1 = Vs/(rb+rpi)           //base current(mA) after
   interchanging stages of JFET and BJT
Vgs1 = beta*Ib1*Rc         //gate to source voltage(V)
   after interchanging stages of JFET and BJT
Vo1 = gm*Vgs1*R             //output voltage(V) after
   interchanging stages of JFET and BJT
Avo1 = Vo1                  //voltage gain after
   interchanging stages of JFET and BJT

//Results
printf ("Avo is %.1f ",Avo)
printf ("Avo1 when BJT and FET stages are reversed
   is %.f",Avo1)
```

Scilab code Exa 4.6 Example

```
//Variable declaration
Cc1 = 1*10^-6                    //coupling capacitor 1(uF)
Cc2 = 1*10^-6                    //coupling capacitor 2 (uF)
Rs = 10^3                        //source resistance(k ohms)
rpi = 2*10^3                     //dynamic junction resistance(k ohms)
Rc = 4500                         //collector resistance(ohms)
Rl = 9*10^3                      //load resistance(k ohms)
w = 100                           //corner frequency(rad/s)

//Calculations
w11 = 1/(Cc1*(Rs+rpi))                   //corner frequency input circuit (rad/s)
w12 = 1/(Cc2*(Rc+Rl))                    //corner frequency output circuit(rad/s)
f = w11/(2*(%pi))                        //lower cutoff frequency(Hz)
Zin = complex((Rs+rpi),-(1/(w*Cc1)))       //input impedance(k ohms)
Zout = complex(Rc,-(1/(w*Cc2)))            //output impedance(k ohms)

//Results
printf ("lower cut-off freq is %.f Hz",f)
```

```
disp ("ohms", Zin ," Zin")
disp ("ohms" ,Zout ,"Zout")
```

Scilab code Exa 4.7 Example

```


//Variable declaration
Re =  1.5*10^3                 //collector resistance(ohms)
Rc = Re
Rs = 600                       //source resistance(ohms)
Rl = 2*10^3                    //load resistance(ohms)
beta = 100                     //common emitter current gain
rpi = 1*10^3                   //dynamic junction resistance(ohms)
f = 50                         //frequency(Hz)

//Calculations
w = 2*f*(%pi)                  //corner frequency(rad/s)
CE = 1/(w*(Rs+rpi))            //capacitance(uF)
Ce = CE*(beta+1)               //capacitance(uF)
w11 = w/10                     //corner frequency input circuit (rad/s)
w12 = w11/20                   //corner frequency output circuit(rad/s)
Cc1 = 1/(w11*(Rs+rpi))         //coupling capacitor 1(uF)
Cc2 = 1/(w12*(Rc+Rl))          //coupling capacitor 2 (uF)

//Results
```

```
printf ("Ce is %.f uF",Ce/1E-6)
printf ("Cc1 is %.1f uF",Cc1/1e-6)
printf ("Cc2 is %.2f uF",Cc2/1E-5)
```

Scilab code Exa 4.8 Example

```


//Variable declaration
gm = 2.5*10^-3                   //transconductance(mS)
Rd = 6*10^3                      //drain resistance(ohms)
rd = 200*10^3                    //dynamic drain resistance(ohms)
Cc1 = 0.12*10^-6             //coupling capacitors(uF)
Cc2 =  Cc1
Rs = 1*10^3                      //source resistance(ohms)
Rg = 0.1*10^6                    //R1||R2
Cgs = 12*10^-9                   //gate to source capacitor(pF)
Cgd = 2*10^-9                    //gate to drain capacitor(pF)
Co1 = 10                          // as Co1 = Cl+Cw = 10

//Calculations
//Part a
Ro = (rd*Rd)/(rd+Rd)                        //equivalent resistance of rd and Rd(ohms)
Vo = -gm*((rd*Rd)/(rd+Rd))                  //as Vgs = Vs
Avo = Vo                                    //Avo = Vo/Vs = (-gm*Vs*((rd*Rd)/(rd+Rd)))/Vs = Vo

//Part b
f11 = 1/(2*(%pi)*Cc1*(Rs+Rg))

//Part c
```

```
Ceq = Cgs+(Cgd*(1+gm*Ro))                    //on application of miller theorem
Co = Co1+Cgd*(1+(1/(gm*Ro)))                 //output capacitance(pF)
f21 = 1/(2*(%pi)*Ceq*((Rs*Rg)/(Rs+Rg)))  //input circuit cutoff frequency(MHz)
f22 = 1/(2*(%pi)*Co*Ro)*10^3             //output circuit cutoff frequency(MHz)
fH = f22                                     //cutoff frequency of high frequency band(MHz)

//Results
printf ("a)mid freq gain is %.1f",Avo)
printf ("b)input circuit cut-off is %.1f Hz",f11)
printf ("c)high freq input cutoff is %.2f and output cutoff is %.2f MHz",f21/1E+3,f22/1E-3)
printf ("high freq cut-off is %.2f MHz",fH/1E-3)
```

Scilab code Exa 4.9 Example

```


//Variable declaration
beta = 50.               //common emitter current gain
R1 = 11.5               //resistance(k ohms)
R2 = 41.4               //resistance(k ohms)
Vcc = 10.                //supply voltage to collector(V)
Rc = 5.                  //collector resistance(k ohms)
Re = 1.                  //emitter resistance(k ohms)
Rs = 1.                  //source resistance(k ohms)
Vbe = 0.7               //base emitter voltage(V)
Rl = 10.                 //load resistance(k ohms)
```

```
Cc1 =  20*10^-6.     //coupling capacitors(uF)
Cc2 = Cc1
Ce = 150*10^-6.         //emitter capacitor(uF)
Cpi = 100
Cu = 5.

//Calculations
//Part a
Rb = (R1*R2)/(R1+R2)                          //R1||R2(k ohms)
Vbb = Vcc*(R1/(R1+R2))                        //suply voltage to base(V)
Ib = (Vbb-Vbe)/(Rb+(Rs*(1+beta)))    //base current(mA)
Ic = beta*Ib                                 //collector current(mA)
Vce = Vcc-(Ic*Rc)-(Ic+Ib)*Re                  //collector to emitter voltage(V)
rpi = (25*beta)*10^-3/Ic                           //dynamic junction resistance(K ohms)

//Part b
rpi = 1                                       //dynamic junction resistance(K ohms)
R = (rpi*Rb)/(rpi+Rb)                         //equivalent resistance(rpi||Rb)
Vbe = (R*Rs)/(R+Rs)                           //base to emitter voltage(V)
Ib1 = Vbe/rpi                                 //base current(mA)
Ro = (Rc*Rl)/(Rc+Rl)                          //Rc||Rl(k ohms)
Vo = -(beta*Ib1*Ro)                          //output voltage(V)
Avo = Vo                                      //voltage gain

//Part c
r1 = (Rs*Rb)/(Rs+Rb)                         //Rs||Rb(k ohms)
```

```
w11 = 1/(Cc1*(Rs+R))                    //low freq cutoff(rad/s)
w12 = 1/(Cc2*(Rc+Rl))                   //high freq cutoff(rad/s)
w1p = 1/((Ce/(beta+1))*(r1+rpi))   //low cutoff freq (rad/s)

//Part d
Co1 = 5                                //as Co1 = Cw+Cl
gm = beta/rpi                          //transconductance(mS)
Ceq = Cpi+(Cu*(1+(gm*Ro)))    //equivalent capacitance(pF)
Rs1 = (Rb*Rs)/(Rb+Rs)                  //Rb||Rs(k ohms)
r2 = (Rs1*rpi)/(Rs1+rpi)               //Rs1||rpi(k ohms)
w21 = 10^12/(Ceq*r2*10^3)                       //low freq cutoff(MHz)

//Results
printf ("a)dc bias values are Vbb : %.2f V, Ib : %.4f mA, Ic : %.2f mA, Vce : %.3f V, rpi : %.f k ohms",Vbb,Ib,Ic,Vce,rpi)
printf ("mid freq gain is %.2f ",Avo)
printf ("low freq cut-off is %.f rad/s",w1p/1E+3)
printf ("high cut-off freq is %.2e rad/s",w21)
```

Scilab code Exa 4.10 Example

```


//Variable declaration
Qcoil = 75.                 //coil inductance
f = 200.                    //frequency(Hz)
BW = 4.                     //bandwidth(kHz)
C = 470*10^-9.             //capacitance(pF)
```

```
//Calculations
//Part a
Qcircuit = f/BW                          //circuit inductance
L = 1/(((2*(%pi)*f)^2)*C)        //inductance(mH)

//Part b
R = Qcircuit*2*(%pi)*f*L          //resistance(k ohms)

//Part c
r = (2*(%pi)*f*L)/Qcoil           //internal resistance(ohms)
req = (Qcoil^2)*r                      //equivalent resistance(k ohms)
ro = (R*req)/(req-R)                    //output resistance(k ohms)

//Part d
BW = 5                                        //bandwidth(kHz)
Qcircuit = f/BW                          //circuit inductance
Req = Qcircuit*2*(%pi)*f*L        //equivalent resistance(k ohms)
Rl = (Req*R)/(R-Req)                   //load resistance(k ohms)

//Results
printf ("a)coil inductance is %.2f mH",L)
printf ("b)circuit output impedance atresonant freq is %.2f K ohms",R/1E+3)
printf ("c)internal resistance ro is %.2f k ohms",ro/1E+3)
printf ("d)value of load resistance is %.2f k ohms",Rl/1E+3)
```

Scilab code Exa 4.11 Example

```


//Variable declaration
fo = 50                          //output frequency(KHz)
L = 10^-3                        //inductance(H)
ro = 100                         //output resistance(k ohms)
Q = 80                           //coil inductance
Ri = 10                          //input resistance(k ohms)
beta = 125                       //common emitter current gain

//Calculations
//Part a
C  = 1/(((2*(%pi)*fo)^2)*L)    //tunning capacitance(nF)
r = (2*(%pi)*fo*L)/Q            //internal resistance(k ohms)
req = (Q^2)*r                    //equivalent resistance(k ohms)
R = (ro*req)/(ro+req)             //ro||req(k ohms)
Avo = -(beta*R)/Ri                //voltage gain

//Part b
Qcircuit = R/(2*(%pi)*fo*L)     //circuit inductance
BW = fo/Qcircuit                  //bandwidth

//Results
printf ("a)value of capacitance is %.f nF",C/1E-3)
printf ("   gain is %.1f",Avo)
```

```
printf ("b)bandwidth is %.f Hz",BW/1E-3)
printf ("Note : value used for beta in texbook is
    wrong in the solution")
```

Scilab code Exa 4.12 Example

```
//Variable declaration

f = 1*10^6                          //radio frequency(Hz)
beta = 50                            //common emitter
    current gain
fT = 5*10^6                         //short circuit current
    gain bandwidth product(Hz)

//Calculations
betaf = fT/f                         //measurement of short
    circuit current gain
fbeta = fT/beta                      //frequency at beta(Hz)

//Results
printf ("frequency is %.f Hz",fbeta)
if fbeta<1*10^6 then
    printf ("transistor is not suitable for 1Mhz
        amplifier as fbeta is less than 1Mhz")
else
    printf ("transistor is suitable for 1Mhz
        amplifier")
end
```

Scilab code Exa 4.13 Example

```
//Variable declaration
rpi = 2                          //dynamic junction resistance(K ohms)
beta = 50.                        //common emitter current gain
f = 1                             //frequency(MHz)
beta1 = 2.5                       //common emitter current gain
f1 = 20*10^6                     //frequency(Hz)

//Calculations
fT = beta1*f1                          //short circuit current gain bandwidth product(Hz)
fbeta = fT/beta                        //frequency at beta(Hz)
Cpi = 1/(2*(%pi)*fbeta*rpi)    //dynamic capacitance(pF)

//Results
printf ("fT is %.f MHz",fT/1e+6)
printf ("fB is %.f MHz",fbeta/1e+6)
printf ("Cpi is %.f pF",Cpi/1e-9)
```

Scilab code Exa 4.14 Example

```


//Variable declaration
R1 = 60                    //resistance(k ohms)
R2 = 140                   //resistance(k ohms)
Rs = 4                     //source resistance(k ohms)
Re = 3                     //emitter resistance(k ohms)
Rc = 4                     //collector resistance(k ohms)
Vcc = 10                   //supply voltage to
```

```
collector(V)
Vbe = 0.7                    //base to emitter voltage(V)
beta = 100                   //common emitter current gain
Avo = -30                    //voltage gain

//Calculations
//Part a
Rb = (R1*R2)/(R1+R2)                          //R1||R2(k ohms)
Vth = (Vcc*R1)/(R1+R2)                        //thevinine's voltage(V)
Ib = (Vth-Vbe)/(Rb+(beta+1)*Re)               //base current (uA)
Ic = Ib*beta                                  //collector current(mA)
Vce = Vcc-(Rc*Ic)-((beta+1)*Ib*Re)            //collector to emitter voltage(V)

//Part b
rpi = ((25*beta)/Ic)*10^-3                 //dynamic junction resistance(k ohms)
r = (Rb*rpi)/(Rb+rpi)                       //resistance across Vs
Ib1 = r/((Rs+r)*rpi)                        //base current(mA)
Rl = (-Rc*Avo)/(Avo+(beta*Ib1*Rc))          //load resistance(k ohms)

//Results
printf ("value of Ic and Vce are %.3f mA and %.2f V",Ic,Vce)
printf ("Rl is %.2f k ohms",Rl)
```

Scilab code Exa 4.15 Example

```
//Variable declaration
R1 = 25.                          //resistances(k ohms)
R2 = 100.                         //resistances(k ohms)
Re = 2.                           //emitter resistance(k ohms)
Vcc = 10.                         //supply voltage to collector
Vbe = 0.7                        //base to emitter voltage(V)
beta = 100.                       //common emitter current gain
Avo = 160                        //voltage gain
Rs = 1                           //source resistance(k ohms)
Vs = 1                           //source voltage(V)
Rl = 12.5                        //load resistance(k ohms)
Rc1 = 20.                         //collector resistance (k ohms)

//Calculations
//Part a
Rb = (R1*R2)/(R1+R2)                 //R1||R2
Vth = (Vcc*R1)/(R1+R2)               //thevinines voltage(V)
Ib = (Vth-Vbe)/(Rb+(beta+1)*Re)      //base current(uA)
Ic = Ib*beta                         //collector current(mA)
rpi = (25*beta)*10^-3/Ic                   //dynamic junction resistance(k ohms)

//Part b
Ib1 = 1/rpi                          //small signal analysis
Rc = -Avo/(-beta*Ib1)                //collector resistance()
```

```

//Part c
r = (Rc1*rpi)/(Rc1+rpi)                    //Rc1||rpi1(k ohms)
Ib2 = (Vs*r)/((1+r)*rpi)                    //base curret (mA)
Rc2 = 6.84                                  //collector resistance(k ohms)
Avo = -(beta*Ib2)*((Rl*Rc2)/(Rl+Rc2))   //voltage gain

//Results
printf ("value of Ic %.3f mA and rpi is %.2f k ohms",Ic,rpi)
printf ("Rc is %.2f k ohms",Rc)
printf ("Avo is %.1f",Avo)
```

Scilab code Exa 4.16 Example

```
//Variable declaration
R1 = 12.                    //resistance(k ohms)
R2 = 100.                   //resistance(k ohms)
Rc = 2                      //collector resistance(k ohms)
Ic = 1.2                    //collector current(mA)
beta = 60                   //common emitter current gain
Ib1 = 1                     //(say)
Rs = 1                      //source resistance(k ohms)
Vs = 1                      //source vcoltage(say)

//Calculations
//Part a
rpi = ((25*beta)/Ic)*10^-3      //dynamic junction resistance(k ohms)
```

```
Rb = (R1*R2)/(R1+R2)                    //R1||R2(k ohms)
r = (Rb*rpi)/(Rb+rpi)                   //Rb||rpi(k ohms)
Ro1 = (Rc*rpi)/(Rc+rpi)                 //Rc||rpi(k ohms)
Vo1 =  -(beta*Ib1*Ro1)              //base to emitter voltage(V)
Vbe2 = Vo1
Ib2 = Vo1/rpi                           //base current(mA)
Ai = Ib2/Ib1                            //current gain

//Part b
Ib11 = (Rs*r)/((Rs+r)*rpi)                  //base currents(mA)
Ib21 = Ib11*Ai                        //base current(mA)
Avo1 =  Ib21*rpi                  //voltage gain
Vo1 = Avo1

//Results
printf ("current gain is %.2f",Ai)
printf ("overall voltage gain is %.2f",Avo1)
printf ("Note : solution in the textbook is incorrect")
```

Scilab code Exa 4.17 Example

```
//Variable declaration
beta = 50.                      //common emitter current gain
R1 = 25.                        //resistance(k ohms)
R2 = 75.                        //resistance(k ohms)
Ic = 1.25                       //collector current(mA)
Vcc = 10                        //supply voltage to collector(V)
s = 10*10^-3                   //signal strength(V)
Rs = 0.5                       //output impedance(k ohms)
Vo = 1                         //output voltage(V)
```

```
Vs = 1.                    //source voltage(V)
Vl = 12                    //load at output terminal(Vl)
Vbe = 0.7                  //base to emitter voltage(V)
Rl = 12

//Calculations
rpi = ((25*beta)/Ic)                //dynamic junction resistance(k ohms)
Rb = (R1*R2)/(R1+R2)                //R1||R2(k ohms)
r = (Rb*rpi*10^-3)/(Rb+rpi*10^-3)               //Rb||rpi(k ohms)
Avo = ((Vo*rpi)/Vcc)                        //voltage gain
Ib = (r*Vs)/(Rs+r)*Vs                       //base current(mA)
Rc = (Rl*Avo)/(beta*Ib*Rl-Avo)             //collector resistance(k ohms)
Vth = (Vcc*R1)/(R1+R2)                      //thevinine's voltage(V)
Ib1 = Ic/beta                              //base current(mA)
Re = (Vth-Vbe-(Rb*Ib1))/((beta+1)*Ib1)      //emitter resistance(k ohms)

//Results
printf ("value of Rc is %.2f and Re is %.2f k ohms",Rc,Re)
printf (" Vth value is wrong substituted in the book " )
```

Scilab code Exa 4.18 Example

```
//Variable declaration
Cpi = 20*10^-9            //opening capacitor(F)
Cu = 5*10^-9
C = 50*10^-9              //here C = Cl+Cw
rpi = 3.75*10^3           //dynamic drain resistance(ohms)
r1 = 4*10^3               //resistance(ohms)
r2 = 42*10^3              //resistance(ohms)
r3 = 303*10^3             //resistance(ohms)
f = 20                     //frequency(Hz)
beta = 100                //common emitter current gain
Rl = 10*10^3              //load resistance(ohms)

//Calculations
//Part a
Req = (((r1*r2)/(r1+r2)+rpi)*r3)/(((r1*r2)/(r1+r2)+rpi)+r3)    //equivalent resistance(ohms)
Ce = (beta+1)/(2*(%pi)*f*Req)
                                    //emitter capacitance(uF)

//Part b
gm = beta/rpi                          //transconductance
Ro = (Rl*r1)/(r1+Rl)                    //output resistance(k ohms)
Ceq = Cpi+(Cu*(1+gm*Ro))                //equivalent capacitance(pF)
Co = C+(Cu*(1+(1/(gm*Ro))))             //output capacitance(pF)
r = (rpi*r1)/(rpi+r1)                   //rpi||r1
w21 = 1/(Ceq*r)                         //lower cutoff frequency(MHz)
w22 = 1/(Co*Ro)                         //higher cutoff frequenct(MHz)

//Part c
```

```
gm = 79.2
Ro = 0.75
Ceqnew = 20+(5*(1+((gm*Ro))))           //as gain is reduced to 75% of original value
wHnew = (10^12)/(Ceqnew*r)/10**6         //corner value of high frequency(Mrad/s)
fHnew = wHnew/(2*(%pi))                  //new value of higher frequency cutoff(KHz)

//Results
printf ("a)value of bypass capacitor Ce is %.f uF",Ce/1E-6)
if w21>w22 then
       printf ("higher frequency is w21")
else
    printf ("higher frequency is w22")
end

printf ("b)high frequency cut-off is %.2f Mrad/s",w22/1E+3)
printf ("c)high frequency cut-off is %.3f MHz",fHnew)
```

Scilab code Exa 4.19 Example

```


//Variable declaration
Vcc = 3.                        //supply voltage to collector(V)
Vee = -3.                       //supply voltage to emitter(V)
r1 = 40.                        //resistance(ohms)
r2 = 25.                        //resistance(ohms)
r3 = 1.56                       //resistance(ohms)
```

```
Vs = 3.                          //source voltage(V)
beta = 200                      //common emitter current gain
r4 = 0.6                         //resistance(ohms)
r5 = 0.15                        //resistance(ohms)
Vbe = 0.7                        //base to emitter voltage
r = 0.5                          //resistance(k ohms)
fL = 20                          //frequency(Hz)
Req1 = 24.24                     //solving r||(Rth+rpi+R)||Re
f = 2                            //non dominant cutoff freq is fL/10 i.e 20/10

//Calculations
//Part a
Vth = Vs-(((Vcc-Vee)/(r1+r2))*r1)                 //thevinine's voltage(V)
Rth = (r1*r2)/(r1+r2)                              //thevinine's voltage(V)
Ib = (Vth-Vbe+Vcc)/(Rth+((r4+r5)*(beta+1)))  //base current(mA)
Ic = Ib*beta                                      //Collector current(mA)
Vo = Vcc-(r3*Ic)                                   //output voltage(V)

//Part b
rpi = (25*beta)/Ic                               //dynamic drain resistance(ohms)
R = r4*(beta+1)                                  //resistance(k ohms)
ro = (rpi*R)/(rpi+R)                              //rpi||R(k ohms)
Req = r+((Rth*ro)/(Rth+ro))                       //equivalent resistance(k ohms)
Cc1 = 1/(Req*2*(%pi)*fL)                     //coupling capacitor(uF)
```

```

//Part c
Ce = 1/(2*(%pi)*fL*Req1)                    //emitter capacitance(uF)
CE = beta*Ce                                  //emitter capacitance(uF) after current gain

//Part d
Ce1 = 1/(2*(%pi)*f*Req1)                    //emitter capacitance(uF)
CE1 = beta*Ce1                                //emitter capacitance(uF) after current gain
Csum = Cc1+CE1                                //total capacitance(uF)

//Results
printf ("a)Ic and Vo are %.2f mA and %.f V",Ic,Vo)
printf ("b)Cc1 is %.3f uF",Cc1/1E-3)
printf ("c)Ce is %.1f uF",CE/1E-3)
printf ("d)Csum is %.3f uF",Csum/1E-2)
```

Scilab code Exa 4.21 Example

```


//Variable declaration
gm = 2                   //transconductance
rd = 200*10^3            //dynamic drain resistance(ohms)
Cgs = 10                 //gate to source capacitance(pF)
Cgd = 0                  //gate to drain capacitance(pF)
Rs = 1*10^3              //source resistance(ohms)
Rg = 1*10^6              //Rg = R1||R2
```

```
Rd = 5*10^3                  //drain resistance(ohms)
Rs1 = 2                       //resistance(k ohms)
Cc1 =  0.1*10^-6          //coupling capacitors(F)
Cc2 = Cc1
Co = 10*10^-12               //output capacitance(F)
Vgs = 1                       //gate to source voltage(V)

//Calculations
//Part a
R = (Rd*rd)/(Rd+rd)        //Rd||rd(k ohms)
Avo =  -Vgs*gm*R         //voltage gain
Vo = Avo

//Part b
w11 = 1/(Cc1*(Rs*Rg))                //corner freq(rad/s)
wL = w11                             //input circuit corner freq(rad/s)

//Part c
w22 = 10^12/((Cgs*R)*10^3)       //output circuit corner frequency(rad/s)
wH = w22/(2*%pi)

//Part d
G = -Avo*wH                                  //gain bandwidth product

//Part e
Rd = 4*10^3                            //drain resistance reduced(ohms)
Rnew = (Rd*rd)/(Rd+rd)                //new resistance(ohms)
Avo1 = -Vgs*gm*Rnew                   //new voltage gain
BWnew = (10^8/Rnew)/(2*%pi)                    //new bandwidth(Mrad/s)
Gnew = -Avo1*BWnew                     //gain bandwidth product new

```

```
//Results
printf ("a)Avo is %.2f",Avo/1E+3)
printf ("b)wL is %.2f rad/s",wL/1E-3)
printf ("c)wH is %.1f MHz",wH/1E+3)
printf ("d)G is %.2f MHz",G/1E+6)
printf ("e)Gnew is %.1f MHz",Gnew/1E+6)
```

Scilab code Exa 4.23 Example

```


//Variable declaration
gm = 1                       //transconductance
rd = 40                      //dynamic drain resistance
    (k ohms)
Cgs = 5                      //gate to source
    capacitance(pF)
Cgd = 1                      //gate to drain
    capacitance(pF)
Cds = 1                      //drain to source
    capacitance(pF)
Avo1 = 20.                   //voltage gain of JFET 1
Avo2 = 8.                    //voltage gain of JFET 2
R1 = 5                       //resistance(k ohms)
R2 = 20                      //resistance(k ohms)
R3 = 8                       //resistance(k ohms)

//Calculations
//Part a
Avo = Avo1*Avo2                  //voltage gain
Ceq1 = Cgs+Cgd*(1+Avo1)          //input crcuit for
    first JFET
Co1 = Cds+(Cgd*(1+(1/Avo1)))     //output crcuit for
    first JFET
Ceq2 = Cgs+Cgd*(1+Avo2)          //input crcuit for
```

```
second JFET
Co2 = Cds+(Cgd*(1+(1/Avo2)))  //output crcuit for second JFET

//Part b
w21 = 1/(R1*Ceq1)             //input circuit frequency
w2 = 10^12/(R2*10^3*(Co1+Ceq2))         //common circuit frequency
w22 = 1/(R3*Co2)              //output circuit frequency


//Results
printf ("a)Avo is %.1f",Avo)
printf ("b)w21,w2,w22 are %.2f Mrad/sec, %.2f Mrad/sec and %.2f Mrad/sec",w21/1E-3,w2/1E+6,w22/1E-3)
printf ("nondominant corner freq is %.2f Mrad/sec",w2/1E+6)
```

Chapter 5

Large Signals Amplifiers

Scilab code Exa 5.1 Example

```


//Variable declaration
Rb=1*10**3                    //base resistance(ohms)
Vcc=20                        //supply voltage(V)
Rc=20                         //collector resistance(ohms)
beeta=25                      //current gain
Vbe=0.7                       //base to emitter voltage(V)
ib=10*10**-3                  //base current(ohms)

//Calculations
Ibq=(Vcc-Vbe)/Rb               //current(A)
Icq=beeta*Ibq                  //current(A)
Vceq=Vcc-(Icq*Rc)              //collector voltage(V)
ic=beeta*ib                    //collector current(A)
Po=((ic/(sqrt(2)))**2)*Rc //output voltage(V)
```

```
Pi=Vcc*Icq                        //input power(W)
eta=(Po/Pi)*100                   //efficiency
Pd=Pi-((Icq**2)*Rc)-Po            //power dissipated(W)

//Results
printf ("input power is Pi %.1f W",Pi)
printf ("output power is Po %.1f W",Po)
printf ("power dissipated is %.1f W",Pd)
```

Scilab code Exa 5.2 Example

```


//Variable declaration
Rl=500                            //load resistance(ohms)
Vceq=50                           //queinscent collector voltage(V)
beetamin=30                       //current gain minimum(at Q)
Icq=0.4                           //queinscent collector current(A)
Ibq=8                             //queinscent base current(mA)

//Calculations
Rac=Vceq/Icq                      //ac resistance(ohms)
beeta=(Icq*10**-3)/Ibq            //current gain
Re=5/Icq                          //emitter resistance(ohms)
Rc=(512.5*Rac)/(512.5-Rac)        //as Re+Rl=500+12.5=512.5
Vcc=5+Vceq+(Icq*Rc)               //supply voltage(V)
```

```
Rb=(beetamin*Re)/10                          //base resistance (ohms)
R1=39.5                                      //solving 125=Rc||(Rl+Re) and Vbb=Vcc*(R1/(R1+R2))
R2=750
Pi=120*Icq                                   //Vcc chosen as 120
r=(Rc*Rl)/(Rc+Rl)
Poac=(100/(2*sqrt(2)))**2/r   //output power(W)
etamax=Poac/Pi                               //efficiency
Poac1=(100/(2*sqrt(2)))**2/Rl  //ac power absorbed by load(W)
eta=Poac1/Pi
Pc=(Icq**2)*Rc                              //power lost in Rc(W)
Pe=(Icq**2)*Re                              //power lost in Re(W)
Pd=Pi-Pc-Pe-Poac                             //power consumed(W)

//Results
printf ("input power is Pi %.1f W",Pi)
printf ("output power is Po %.2f W",Poac)
printf ("dissipated power is %.2f W",Pd)
printf ("values of R1,R2,Re and Rc are %.1f ohms, %.1f ohms, %.1f ohms and %.f ohms resp.",R1,R2,Re,Rc)
printf("Note : Calculated value of Rc is wrong in the book")
```

Scilab code Exa 5.3 Example

```


//Variable declaration
```

```
Pmax=10                               //power maximum(W)
Ic=1                                  //collector current(A)
Vcemax=100                            //max collector to emitter current(V)
Vcemin=2                              //min collector to emitter current(V)

//Calculations
//Part a
Vceq=46                             //Vce at Q point
Icq=0.21                            //Ic  at Q point
Vcc=92                              //supply voltage(V)
ic=0.42                             //collector current(A)

//Part b
Rl=Vceq/Icq                               //load resistance(ohms)

//Part c
Pi=Vcc*Icq                                //input power(W)
Po=((ic/(2*sqrt(2)))**2)*Rl   //output power(W)
eta=(Po/Pi)*100                           //efficiency

//Results
printf ("Rl for maximum power input is %.f ohms",Rl)
printf ("input power is is %.1f W",Pi)
printf ("Po is %.1f",Po)
printf ("eta is %.1f %%",eta)
```

Scilab code Exa 5.4 Example

```


//Variable declaration
```

```
Vcc=15                     //supply voltage(V)
beeta=40.                  //current gain
Icq=5.                     //Ic at Q(mA)
Vceq=7.5                   //Vce at Q(V)
icswing=10                 //swing in ic(mA)

//Calculations
//Part a
Rl=Vceq/Icq*10**-3         //load resistance(ohms)

//Part b
Ibq=Icq/beeta              //base current at Q(uA)

//Part c
ibswing=icswing/beeta                          //swing in ib(mA)
Pac=Rl*(icswing/(2*sqrt(2)))**2     //ac power(W)
Pdc=Vcc*(Icq*10**-3)                           //dc power(W)
eta=(Pac/Pdc)*100                              //efficiency

//Results
printf ("a)value of Rl is %.f ohms",Rl/1E-6)
printf ("b)Ibq is %.f uA",Ibq/1E-3)
printf ("c)ac power output is %.2f mW",Pac/1E-3)
printf ("efficiency is %.1f %%",eta)
printf ("corresponding swing in ib is %.2f mA",ibswing)
```

Scilab code Exa 5.5 Example

```


//Variable declaration
Vcc=10                    //supply voltage(V)
```

```
Vce=10
Icq=140*10**-3                    //Ic at Q point(A)
Rl=8                              //load resistance(ohms)
vce=16                            //instantaneous collector to emitter voltage(V)
ic=235*10**-3                     //instantaneous collector current(A)

//Calculations
RL=Vcc/Icq
r=sqrt(RL/Rl)                                    //load resistance for max ac swing(ohms)
Po=(vce*ic)/(2*sqrt(2)*2*sqrt(2))     //output power(W)
Pi=Vcc*Icq                                             //input power(W)
eta=Po/Pi                                              //efficiency
Pd=Pi-Po                                               //dissipated power(W)

//Results
printf ("a)transformation ratio is %.f",r)
printf ("c)power output is %.2f W",Po)
printf ("efficiency is %.2f %%",eta*100)
```

Scilab code Exa 5.6 Example

```


//Variable declaration
Rl=4.5                         //load resistance(ohms)
Vceq=50                        //Vc at point Q(V)
Icq=400*10**-3                 //Ic at Q(A)
Re=12.5                        //emitter resistance(ohms)
```

```
Vcemax=90                  //from figure
Vcemin=10                  //from figure
Icmax=730                  //max Ic(mA)
Icmin=30                   //min Ic(mA)

//Calculations
//Part a
Rac=Vceq/Icq                  //ac resistance(ohms)
n=sqrt(Rac/Rl)             //as n=N1/N2 and Rac=(N1/N2)^2*Rl

//Part b
Vcc=Vceq+(Icq*Re)             //supply voltage(V)

//Part c
vce=Vcemax-Vcemin                                   //instantaneous collector to emitter voltage(V)
ic=Icmax-Icmin                                         //instantaneous collector current(mA)
Po=(vce*ic)/((2*sqrt(2))*(2*sqrt(2)))        //output voltage(V)
Pi=Vcc*Icq                                                //input voltage(V)
eta=(Po/Pi)*100                                        //efficiency
Pd=Pi-(Icq**2*Re)-Po*10**-3              //dissipated power(W)

//Results
printf ("a)transformation ratio is %.2f",n)
printf ("b)Vcc is %.1f V",Vcc)
printf ("c)power efficiency for the load is %.1f %%",eta/1E+3)
printf ("power dissipated is %.1f W",Pd)
```

Scilab code Exa 5.7 Example

```

//Variable declaration
Vcc=30                          //supply voltage(V)
Rl=16                           //load resistance(ohms)
n=2                             //transformation ratio
Im=1                            //peak value of current(A)
etamax=78.54                    //max efficiency(%)

//Calculations
//Part a
Rl1=Rl*(n/2)**2                    //load resistance(ohms)
Pi=(2*Vcc*Im)/%pi               //input power(W)
Pimax=(2*Vcc**2)/((%pi)*Rl1) //input power max(W)

//Part b
Po=((Im**2)*Rl1)/2                 //output power(W)
Pomax=(Vcc**2)/(2*Rl1)             //output power max(W)

//Part c
eta=Po/Pi                          //efficiency


//Part d
P=((2*Vcc*Im)/%pi)-((Im**2*Rl1)/2) //Power dissipated by transistors(W)
Pd=P/2                                   //power dissipated by each transistors
Pmax=(2*Vcc**2)/((%pi)**2*Rl1)      //max power
```

```
dissipated by transistors
Pdmax=Pmax/2                                   //max power dissipated by each transistor

//Results
printf ("a)input power is %.1f W and  max input power is %.2f W",Pi,Pimax)
printf ("b)output power %.1f W and max output power is %.2f W",Po,Pomax)
printf ("c)power efficiency for the load is %.2f %% and its max value is %.2f %%",eta/1E-2,etamax)
printf ("power dissipated by each transiator is %.1f W and  max value is %.1f W",Pd,Pdmax)
```

Scilab code Exa 5.8 Example

```

//Variable declaration
Pd=10

//Calculations
//Part a
Poacmax=10.                    //as Pd=Po(ac)max by class A

//Part b
Pd=2*Poacmax                   //power dissipated(W)
Poacmax1=146/2                 //max output power by class B
f=Poacmax1/Poacmax             //factor by which power of class B is greater than class A

//Results
printf ("maximum signal output powerclass A produce is %.1f W",Poacmax)
```

```
printf ("maximum signal output powerclass  produce is %.1f W",Poacmax1)
printf ("factor by which power in class b is larger than power in class A transformer is %.1f",f)
```

Scilab code Exa 5.9 Example

```


//Variable declaration
Vcc=30.                          //supply voltage(V)
Im=1                             //peak value of current(A)
Rl=10.                           //load resistance(ohms)

//Calculations
//Part a
Pi=(Vcc*Im)/%pi           //input power(W)
Pimax=(Vcc**2)/(%pi*2*Rl) //max input power(W)

//Part b
Po=((Im**2)*Rl)/2              //output power(W)
Pomax=(Vcc**2)/(8*Rl)          //output power max(W)

//Part c
eta=Po/Pi                    //efficiency
etamax=Pomax/Pimax           //efficiency max

//Part d
Pd=Pi-Po                                  //Power dissipated by transistors(W)
Pmax=(Vcc**2)/(2*(%pi)**2*Rl)    //max power dissipated by transistors
```

```

//Results
printf ("a)input power is %.2f W and max input power is %.2f W",Pi,Pimax)
printf ("b)output power is %.1f W and max output power is %.2f W",Po,Pomax)
printf ("c)power efficiency for the load is %.2f %% and its max value is %.2f %%",eta/1E-2,etamax/1E-2)
printf ("power dissipated and its max value are %.2f W and %.2f W",Pd,Pmax)
```

Scilab code Exa 5.10 Example

```


//Variable declaration
P1=2                          //transistor power(W)
Rl=5*10**3.                   //load resistance()
Ic=35                         //collector current(mA)

//Calculations
Bo=40-Ic
B1=sqrt((2*P1)/Rl)
B2=Bo
D2=(B2/B1)*100                //second harmonic distortion(%)

//Results
printf ("second harmonic distortion is %.2f %%",(D2/1E+3))
```

Scilab code Exa 5.12 Example

```


//Variable declaration
Vcc=15.                                 //supply voltage(V)
Rl=10.                                  //load resistance(ohms)

//Calculations
//Part a
Immax=Vcc/Rl                            //max peak current(A)
Irmsmax=Immax/(sqrt(2))          //max rms current(A)
Pomax=Irmsmax**2*Rl                     //max output power(W)
Pi=(2*Vcc*Immax)/%pi              //max input power(W)
eta=Pomax/Pi                            //efficiency

//Part b
Im=(2*Vcc)/(%pi*Rl)                              //peak current(A)
Pdmax=((2*Vcc*Im)/(%pi))-((Im**2*Rl)/2)      //max power dissipated(W)
eta1=((Im**2)*Rl*%pi)/(2*2*Vcc*Im)           //efficiency

//Results
printf ("a)max signal output power,collector dissipation  are %.2f W , %.2f W and efficiency is %.2f %%",Pomax,Pi,eta/1E-2)
printf ("b)max dissipation of each transistor and corresponding efficiency is %.2f W and %.1f resp.",Pdmax,eta1)
```

Scilab code Exa 5.13 Example

```
//Calculations
eta=0.5                    //As Po(ac)=Vcc^2/2*pi^2*Rl and
    Pi(dc)=Vcc^2/pi^2*Rl
                           //put these in eta=Po(ac)/Pi(dc
                              ) which is 1/2=0.5

//Results
printf("push pull amplifier efficiency is %.f %%",
   eta/1E-2)
```

Chapter 6

Feedback Amplifiers And Oscillators

Scilab code Exa 6.1 Example

```
//Variable declaration
Vo=12.                //output voltage(V)
f=1.5*10**3           //frequency(Hz)
h=0.25                //second harmonic content(%)
ho=2.5                //reduced harmonic content of
   output(%)
A=100                 //power amplifier gain

//Calculations
Vd=Vo*h                  //second harmonic content in
   output(V)
Vd1=Vo*ho                //reduced value of second
   harmonic content(V)
beta=((Vd1/Vd)-1)/A   //feedback gain from formula
   Vd1=Vd/(1+beta*A)
Vs=Vo*(1+beta*A)/A    //signal voltage(V) from
   formula (A/(1+Beta*A))*Vs
V=Vo/A                   //signal input needed without
   feedback
```

```
s=Vs/V                    //additional signal amplification needed before feedback amplifier

//Results
printf ("feedback gain is %.2f",beta)
printf ("signal input to the overall system is %.1f",s)
```

Scilab code Exa 6.2 Example

```
//Variable declaration
w2=10**4.                  //corner frequency(rad/s)
w2new=10**5.               //new corner frequency(rad/s)
Ao=1000.                   //high frquency response

//Calculations
beta=((w2new/w2)-1)/Ao //feedback factor
Anew=Ao/(1+beta*Ao)    //overall gain of amplifier from formula w2new=w2(1+beta*Ao)
p=w2*Ao                    //gain bandwidth product without feedback from formula Anew=Ao/1+beta*Ao
pnew=Anew*w2new            //gain bandwidth product with feedback

//Results
printf ("beta is %.3f",beta)
printf ("overall gain is %.1f",Anew)
printf ("gain-bandwidth products with and without feedback are %.1f and %.1f resp.",p,pnew)
```

Scilab code Exa 6.3 Example

```
//Variable declaration
```

```
A=100.                                    //high frquency response
Af=100                                    //gain
A1=A**2                                   //forward gain
A1new=50                                  //gain reduces to 50%

//Calculations
beta=((A1/Af)-1)/A1                       //feedback factor
Afnew=A1new**2/(1+beta*A1new**2)          //new value of A
g=Af-Afnew                                //reduction in overall gain

//Results
printf ("%% change in gain of feedback unit is %.2f",g)
```

Scilab code Exa 6.4 Example

```
//Variable declaration
beta=0.008                          //positive gain

//Calculations
Ao=-(8/beta)**(1/3)                 //A=Ao/2,so beta(A^3)=-1

//Results
printf ("%% change in gain of feedback unit is %.f",Ao/1E-1)
```

Scilab code Exa 6.5 Example

```
//Variable declarations
A = complex(0,60)                        //amplifier
B = complex(0,30)                        //amplifier
AB = A*B
C = (1+A)/AB                             //condition for
   oscillation
phi = phasemag(C)                     //phase

//Result
printf("C = %.4f with phase = %.2f ",abs(C),phi)
```

Scilab code Exa 6.7 `Example`

```
//Variable declaration
Rbb=8*10**3                         //base resistance(k
   ohms)
eta=0.7                            //efficiency
R1=0.2                             //R1(k ohms)
Rt=40*10**3                        //Rt(ohms)
Ct=0.12*10**-6                     //capacitance(F)
Vv=2                               //capacitor is charged
   to voltage(V)
Iv=10*10**-3                       //current to capacitor(A
   )
Ip=10*10**-3                        //peak current(A)
Vd=0.7                             //diode voltage(V)
V=12.                               //voltage(V)

//Calculations
//Part a
Rb1=eta*Rbb     //base resistance(ohms)
Rb2=Rbb-Rb1                  //base resistance(ohms)

//Part b
```

```
Vp=Vd+((Rb1+R1)*V/(Rbb+R1))     //peak voltage(V)

//Part c
Rtmin=(V-Vv)/Iv            //Rt minimum(k ohms)
Rtmax=(V-Vp)/Ip            //Rt minimum(k ohms)

//Part d
Rb11=.12                   //resistance during discharge(ohms)
t1=Rt*Ct*1.27              //charging time(mS)
t2=(Rb11+R1)*Ct*1.52       //discharging time(uS)
T=t1+t2                    //cycle time
foscE=1/T                  //oscillations frequency(Hz)
foscA=1/(Rt*Ct*1.2)        //oscillations frequency(Hz)

//Part e
vR1=(R1*V)/(R1+Rbb)                //vR1 at discharging period
vR1d=(R1*(Vp-Vd))/(R1+Rb11)        //vR1 at discharging period

//Results
printf ("Rb1 and Rb2 are %.1f k ohms and %.1f k ohms resp.",Rb1/1E+3,Rb2/1E+3)
printf ("Vp is %.1f V",Vp)
printf ("Rtmin is %.f k ohms and Rtmax is %.f k ohms, hence Rt is in the range",Rtmin/1E+3,Rtmax/1E+1)
printf ("foscE is %.f Hz and foscA is %.f Hz",foscE,foscA)
printf ("vR1 is %.3f and vRd1 is %.2f V ",vR1/1E-3,vR1d)
printf("(range of Rt is wrong in the book)")
```

Scilab code Exa 6.8 Example

```
//Variable declaration
A=1500                              //voltage gain
beta=1/25.                          //current gain

//Calculations
//Part a
Af=A/(1+A*beta)                      //voltage gain with feedback

//Part b
g=0.1                               //amplifier gain changes by 10%=0.1
gf=g/(1+A*beta)                     //% by which its gain in feedback mode changes dAf/Af

//Results
printf ("Amplifier gain with feedback is %.1f ",Af)
printf ("%% by which gain in feedback changes is %.3f %%",gf/1E-2)
```

Scilab code Exa 6.9 Example

```
//Variable declaration
A=500                           //voltage gain
beta=1/20.                      //current gain
Ro=50*10**3                     //output resistance(ohms)
Ri=1.5*10**3                    //input resistance(ohms)

//Calculations
//Part a
Af=A/(1+A*beta)                 //voltage gain with feedback

//Part b
Rif=Ri*(1+(A*beta))              //input resistance(k
```

```
ohms)
Rof=Ro/(1+A*beta)              //output resistance(k ohms)

//Results
printf ("Amplifier gain is %.2f",Af)
printf ("input resistance is %.f K ohms and output resistance is %.2f kW",Rif/1E+3,Rof/1E+3)
```

Scilab code Exa 6.10 Example

```
//Variable declaration
Ro=50*10**3                    //output resistance(ohms)
Rd=10*10**3                    //drain resistance(ohms)
R1=800*10**3                   //resistance(ohms)
R2=200*10**3                   //resistance(ohms)
gm=5500*10**-6                 //transconduuctance(us)

//Calculations
r=(Rd*Ro)/(Rd+Ro)               //Rd||Ro
R=R1+R2                         //combined resistance of R1 and R2
Rl=(R*r)/(R+r)                  //load resistance(ohms)
A=-gm*Rl                        //voltage gain without feedback
beta=R2/(R1+R2)                 //current gain
Af=A/(1+A*beta)                 //voltage gain with feedback

//Results
printf ("Amplifier gain with feedback is %.1f and without feedback is %.1f",Af/1E+1,A)
```

Scilab code Exa 6.11 Example

```
//Variable declaration
Re=1.25*10**3                  //emitter resistance(ohms
    )
Rc=4.8*10**3                    //collector resistance(
    ohms)
Rb=800*10**3                   //base resistance(ohms)
rpi=900                        //dynamic resistance(ohms
    )
Vcc=16                         //supply voltage(V)
beta=100.                      //current gain

//Calculations
A=-(beta/rpi)                 //amplifier voltage gain
B=-Re
V=(A*Rc)/(1+B*A)              //V=Vo/Vs

//Results
printf ("Amplifier voltage gain is %.1f",V)
```

Scilab code Exa 6.12 Example

```


//Variable declaration
C1=800*10**-9                           //capacitance(F)
C2=2400*10**-9                          //capacitance(F)
L=50*10**-6                             //inductance(H)

//Calculations
```

```
Ceq=(C1*C2)/(C1+C2)                     //equivalent
   capacitance(F)
fo=1/(2*%pi*sqrt(L*Ceq))  //output frequency(Hz)

//Results
printf ("the oscillation frequency is %.2f KHz",fo/1
   E+3)
```

Scilab code Exa 6.13 Example

```


//Variable declaration
C=200*10**-9                //capacitance(F)
Lrcf=0.5*10**-3             //shunt across L2
L1=800*10**-6               //inductance(H)
L2=800*10**-6               //inductance(H)
M=200*10**-6

//Calculations
L21=(L2*Lrcf)/(L2+Lrcf)                    //effective
    value of L2(uH)
Leq=L1+L21+2*M                             //
   equivalent inductance(H)
fo=1/(2*%pi*sqrt(Leq*C))         //output frequency(
   Hz)

//Results
printf ("the oscillation frequency is %.2f KHz",fo/1
   E+3)
```

Chapter 7

Operational Amplifiers

Scilab code Exa 7.1 `Example`

```
//Variable declaration
V1=120                     //negative terminal Vn(uV)
V2=80                      //positive terminal Vp(uV)
Ad=10**3                   //difference mode gain


//Calculations
Vd=V1-V2                   //difference mode signal(uV)
Vc=(V1+V2)/2               //common mode signal(uV)

//Part a
CMRR=100.                       //common mode rejection ratio
Vo=Ad*Vd*(1+(Vc/(CMRR*Vd)))   //output voltage(mV)

//Part b
CMRR=10**5.                        //common mode rejection ratio
Vo1=Ad*Vd*(1+(1/CMRR)*(Vc/Vd)) //output voltage(mV)

//Results
```

```
printf ("output voltage is %.f mV",Vo/1E+3)
printf ("output voltage is %.f mV",Vo1/1E+3)
```

Scilab code Exa 7.2 Example

```
//Variable declaration
deltavi=0.5                //change in vi(V)
deltat=10                  //change in time(us)
s=1                        //slew rate(V/us)

//Calculations
Kvf=(s*deltat)/deltavi     //closed loop gain of
    amplifier

//Results
printf ("closed loop gain of amplifier is %.1f",Kvf)
```

Scilab code Exa 7.3 Example

```


//Variable declaration
f=50*10**3.                        //OPAMP freequency(Hz)
Vm=0.02                            //maximum value of
    signal voltage(V)
S=.5*10**6                           //slew rate(V/s)

//Calculations
Kvf=S/(2*(%pi)*f*Vm)       //closed loop gain of
    amplifier

//Results
printf ("closed loop gain of amplifier is %.f",Kvf)
```

Scilab code Exa 7.4 Example

```
//Variable declaration
Ic=100                  //current at quinscent point(uA)
beta=2000.              //current gain
Ad=250                  //difference mode gain
CMRR=5000               //as 74 dB=5000,common mode rejection ratio(dB)

//Calculations
rpi=(25*beta)/Ic        //dynamic internal resistance(k ohms)
gm=beta/rpi             //transconductance(mS)
Re=CMRR/gm              //emitter resistance(k ohms)
Rc=(Ad*2)/gm            //collector resistance(k ohms) from formula Ad=gmRc/2
Rin=2*rpi               //input resistance(k ohms)

//Results
printf ("Re is %.1f k ohms",Re)
printf ("Rc is %.1f k ohms",Rc)
printf ("input resistance is %.1f k ohms",Rin)
```

Scilab code Exa 7.6 Example

```
//Variable declaration
Icq=.428                //current at quinscent point(uA)
beta=200.               //current gain
                        //as 74 dB=5000,common mode rejection ratio(dB)
Rc=10.                  //collector resistance(k ohms)
```

```
Re=16.                  //emitter resistance(k ohms)
Vcc=15.                 //supply voltage(V)

//Calculations
//Part b
Ibq=Icq/beta             //Ib at Q(uA)
rpi=(25*beta)/Icq        //dynamic resistance(k ohms)
gm=beta/rpi              //transconductance

//Part b
vo1=Vcc-(Icq*Rc)        //terminal 1 voltage(V)
vo2=vo1                 //terminal 2 voltage(V)

//Part c
Ad=(gm*Rc)/2            //differential mode gain
Ac=Rc/(2*Re)            //common mode gain
CMRR=Ad/Ac              //common mode rejection ratio

//Part d
Rid=2*rpi                          //differential input resistance(k ohms)
rpi=11.7                           //dynamic resistance(k ohms)
Ric=rpi+(2*(beta+1)*Re)            //common mode input resistance(k ohms)

//Results
printf ("Icq is %.3f mA,and Ibq is  %.2f uA",Icq,Ibq/1E-3)
printf ("vo1 and vo2 have same value as %.1f V",vo1)
printf ("Ad : %.f , Ac : %.3f and CMRR is %.f",Ad/1E-3,Ac,CMRR/1E-3)
printf ("Rid is %.1f K ohms and Ric is %.2f  Mohms",Rid/1E+3,Ric/1E+3)
```

Scilab code Exa 7.7 Example

```
//Variable declaration
R1=10.                    //series resistance(K ohms)
Rf=10**3.                 //feedback resistance(k
    ohms)
vo=-5.                    //output voltage(V)
Ri=1000                   //input resistance(k ohms)
Av=2.5*10**5              //gain

//Calculations
v1=-vo*(R1/Rf)            //input signal voltage(V)
vi=-vo/Av                 //inverting voltage(V)
i1=((v1*10**-3)-vi)/R1    //current through R1(uA)
ii=vi/Ri                  //inverting current(uA)
iF=-ii                    //forward current(uA)

//Results
printf ("value of vi is %.e mV",vi)
printf ("value of ii: %.e uA i1: %.e uA and iF is %.
    e uA",ii,i1,iF)
```

Scilab code Exa 7.8 Example

```
//Variable declaration
Vs=4                     //source voltage(V)
R1=10.                    //resistance(k ohms)
Vb=2                 //voltage at point A and point
    B
Va=2
Rf=30                    //forward resistance(k ohms)

//Calculations
I=(Vs-Vb)/R1            //current(mA)
Vo=(-I*Rf)+Vb           //output voltage(V)
```

```
//Result
printf ("output voltage %.1f  V",Vo)
```

Scilab code Exa 7.9 Example

```
//Variable declaration
Rf=2                    //as vs=2sinwt and vo=(1+Rf/Rs)*vb and vB=vA=vs
Rs=1


//Calculations
vo=(1+(Rf/Rs))*2          //output voltage(V)

//Result
printf ("output voltage %.1f sinwt",vo)
```

Scilab code Exa 7.10 Example

```
//Variable declaration
Ro=100.                    //output resistance(ohms)
vo=10.                     //output voltage(V)
A=10**5.                   //gain
Ri=100*10**3               //input resistance(ohms)
Rs=1*10**3.                //resistance(ohms)
Rl=10*10**3                //load resistance(ohms)

//Calculations
//Part i
iL=vo/Rl                     //load current(mA)
Avi=vo+(iL*Ro)               //voltage gain without feedback
```

```
vi=Avi/A                          //voltage(V)
ii=vi/Ri                          //current(A)
vs=vo+ii*(Rs+Ri)                  //source voltage(V)

//Part ii
Avf=vo/vs                        //voltage gain with feedback


//Part iii
Rif=vs/ii                     //input resistance(ohms)
Rof=Ro/A                      //output resistance(ohms)

//Results
printf ("vs is %.4f v",vs)
printf ("vo/vs that is Avf is %.f",Avf)
printf ("input and output resistances are %.2f , %.3f ohms",Rif,Rof)
```

Scilab code Exa 7.11 Example

```
//Variable declaration
Vb=3                             //voltage at A and B
Va=Vb
R1=40*10**3.                        //input resistance(ohms)
t=50*10**-3                         //time after switch is open(mS)
V1=5                                //input voltage(V)

//Calculations
//Part a
vo=-3                               //as Va=Vb=3

//Part b
i1=(V1-Vb)/R1                       //input current(A)
```

```
vo1=(-250*50*10**-3)- Vb            //vo at 50 mS

//Result
printf ("output voltage %1f V",vo1)

// Note : Answer in book is wrong.
```

Scilab code Exa 7.14 Example

```


//Variable declaration
BW=30*10**3                 //specified bandwidth(k Hz)
fc=18*10**3                 //centered frequency(Hz)
R1=20                       //resistance(k ohms)
R2=180                      //resistance(k ohms)
C=1.2*10**-9                //capacitance(F)
G=40                        //pass band gain(dB)
g=20                        //pass region gain(dB)

//Calculationsv
fc1=fc-(BW/2)               //high pass section frequency(Hz)
fc2=fc+(BW/2)               //low pass section frequency(Hz)
Rfc1=1/(2*%pi*fc1*C)    //high pass section resistance(k ohms)
Rfc2=1/(2*%pi*fc2*C)    //low pass section resistance(k ohms)
Gfc1=G-g                    //gain at frequency 0.3KHz(dB)
Gfc2=G-2*6                  //gain at frequency 132KHz(dB)

```

```
//Results
printf ("R1 and R2 are %.1f K ohms and %.1f K ohms",R1,R2)
printf ("Rfc1 is %.f k ohms and Rfc2 is %.f k ohms",Rfc1/1E+3,Rfc2/1E+3)
printf ("filter gain at frequencies 0.3 KHz is %.1f dB and 132 k Hz are %.1f dB",Gfc1,Gfc2)
```

Scilab code Exa 7.21 Example

```
//Variable declaration
R=250                    //resistance(k ohms)

//Calculations
//part a
R1=-R/(-5)        //as vo=-5va+3vb(given),so when vb=0,vo/voa=-250/R1=-5

//part b
R2=R1/(2-1)       //as va=0
                  //vx=(R1/R1+R)*vob=(1/6)*vb
                  //vy=(R2/R1+R2)*vb
                  //vx=vy
                  //(1/6)*vob=(R2/R1+R2)*vb
                  //vob=3vb
                  //(1/6)*3=R2/(50+R2)

//Result
printf ("R1 and R2 are %.1f K ohms and %.1f K ohms",R1,R2)
```

Scilab code Exa 7.22 Example

```
//Variable declaration
R1=10*10**3                              //resistance(k
    ohms)
C1=10**-6                                //capacitance(uF)
C=0.1*10**-6                             //capacitance(uF)
R=100*10**3                              //resistance(k
    ohms)

//Calculations
//part b
wc1=1/C1*R1                            //angular frequency(
    rad/s)
wc2=1/C*R                              //angular frequency(
    rad/s)
wc=wc2                             //angular frequency(rad/
    s)
wc1=wc2

//Results
printf ("wc1 is %.2f rad/s",wc1/1E+10)
printf ("wc2 is %.2f rad/s",wc2/1e+10)
```

Scilab code Exa 7.23 Example

```
//Variable declaration
vo1=5                      //say (V)
K=25                       //proportionality constant
Q=250                      //volume of fluid passed
    across metering point(cm^3)
R1=2.5                      //output resistance(k ohms)

//Calculations
C1=(K*Q)/(R1*vo1)        //capacitor(nF)

//Results
```

```
printf("C1 is %.f uF",C1/1E+1)
printf("vo1 is -5 V when Q=250 cm^3")
```

Chapter 8

Multivibrators And Switching Regulators

Scilab code Exa 8.1 Example

```
//Variable declaration
C=0.1                          //capacitance(uF)
R1=10                          //resistance(k ohms)
R2=2.3                         //resistance(k ohms)
Vcc=12.                        //supply voltage(V)
Rl=10**3.                      //resistance(k ohms)

//Calculations
//Part a
f=1/(0.693*C*(R2+R1/2))        //frequency(Hz)

//Part b
D=(1+(R2/R1))/(1+2*(R2/R1))*100            //duty cycle

//Part c
//(i)
T1=0.693*C*(R1+R2)                          //time period through R1(ms)
```

```
T2=0.693*R2*C                                //time
   period through R2(ms)
Pavg=(Vcc/Rl)**2*(T1/(T1+T2))                //average
   power dissipated during current sourcing(mW)

//Part d
Pavg1=(T2/(T1+T2))*(Vcc/Rl)**2              //average
   power dissipated during current sinking(mW)

//Results
printf (" %.2f kHz",f)
printf ("duty cycle is %.2f %%",D)
printf ("average power dissipated in current
   sourcing is %.3f mW",Pavg/1E-3)
printf ("average power dissipated in current sinking
    is %.3f mW",Pavg1/1e-3)
```

Scilab code Exa 8.2 Example

```


//Variable declaration
t=1                                 //time constant
e=1.8                               //e=R1/R2 min=1.8
e1=9.                                //e1=R1/R2 max=9

//Calculations
Betamin=1/(1+e)                   //current gain
   minimum
Betamax=1/(1+e1)                  //current gain
   maximum
Tmax=2*t*log((1+Betamin)/(1-Betamin))
Tmin=2*t*log((1+Betamax)/(1-Betamax))
fmin=1/Tmax                       //minimum freq(Hz)
fmax=1/Tmin                       //maximum freq(k Hz)
```

```
//Results
printf ("fmin is %.f Hz and fmax is %.1f KHz",fmin/1E-3,fmax)
```

Scilab code Exa 8.3 Example

```


//Variable declaration
C=0.01                          //capacitance(uF)
R2=15                           //resistance(k ohms)
Va2=4                           //voltage(V)
Vcc=15.                         //supply voltage(V)
R1=33                           //resistance(k ohms)

//Calculations
Va1=0.67*Vcc                    //voltage(V)
Vamax=Va1+Va2                   //Va maximum(V)
Vamin=Va1-Va2                   //Va minimum(V)
T1max=C*(R1+R2)*(log((1-(Vamax/(2*Vcc)))/(1-(Vamax/Vcc))))   //time period(ms)
T1min=C*(R1+R2)*(log((1-(Vamin/(2*Vcc)))/(1-(Vamin/Vcc))))   //time period(ms)
T2=0.693*R2*C
fmax=1/(T1min+T2)                          //maximum frequency(K Hz)
fmin=1/(T1max+T2)                          //miniimum frequency(K Hz)

//Results
printf ("minimum freq is %.2f",fmin)
printf ("maximum freq is %.2f",fmax)
printf(" (solution given in the textbook is incorrect)");
```

Scilab code Exa 8.4 Example

```
//Variable declaration
Vi=25                              //input voltage(V)
Vsmax=30                           //supply voltage max(V)
Vomin=12                        //output minimum voltage or load voltage(V)
Vl=12
R1=20                              //load voltage(V)
Io=15.                             //output current(mA)
Iq=3.                              //quinscent current of regulator(mA)
Vo=20.                             //output voltage(V)

//Calculations
//Part a
//(i)
Vimax=Vsmax                          //maximum permissible voltage(V)
Ro=0                                 //for Vomin=beta=0
//(ii)
Vomax=Vi-2
betaVomax=Vomax-Vomin                            //output voltage(V)
R2max=(R1*betaVomax)/(Vomax-betaVomax)   //R2max(k ohms)
//(iii)
R3=betaVomax/Io                                  //R3(k ohms)

//Part b
Vt=(Iq*betaVomax)/Io                            //common terminal fall(V)
Vomin1=Vl+Vt                                    //voltage
```

```
output minimum(V)

//Part c
betaVo=Vo-Vl                                 //output voltage(V)
beta=betaVo/Vo                               //current gain
R2=(R1*betaVo)/(Vo-betaVo)                   //R2(ohms)

//Results
printf ("a)i)max permissible supply voltage is %.1f V",Vimax)
printf ("ii)output voltage range for Vi=25V is %.1f V to %.1f V and R2max is %.f k ohms",Vomin,Vomax,R2max)
printf ("iii)R3 is %.2f kohms kohms",R3)
printf ("b)Vomin is %.1f V",Vomin1)
printf ("c)R2 is %.2f ohms and R3 is %.3f ohms",R2,R3)
```

Scilab code Exa 8.5 Example

```
//Variable declaration
A=.0025                      //voltage gain
Vi=8                         //input voltage(V)
R2=1.5                       //resistance 2(k ohms)
R1=1                         //resistance 1(k ohms)
Vl=5                         //load voltage(V)

//Calculations
beta=R2/(R1+R2)                //current gain
Vo=Vl/(1-beta)                 //output voltage(V)
Vo1=(A*Vi)/(1+(A*beta)-beta)   //output voltage ripple if Vi=8Vp-p

//Results
```

```
printf ("Vo is %.1f V",Vo)
printf ("expression of output voltage ripple %.2f Vp
    -p",Vo1)
```

Scilab code Exa 8.6 Example

```
//Variable declaration
Ro=7.5                                          //output
    resistance(ohms)
hfe=50
Ve=20                                           //voltage given
     to emitter(V)
Vbe=0.8                                         //base to
    emitter voltage(V)
Vc=15                                           //collector
    voltage(V)
P=12                                            //maximum power
     dissipation(W)
Ib1=5                                           //for minimum
    load current Il=0,Ib=5

//Calculations
Io=(Vc/Ro)*10**3                                 //output
    current(A)
Il=76                                            //load current
    (mA)
Is=Il+5                                          //supply
    current(mA)
Ic=Io-Is                                         //collector
    current(A)
Ib=Ic/hfe                                        //base current
    (mA)
Ie=Ic-Ib                                         //emitter
    current(mA)
Pt=(Ve*Ie)-(Vc*Ic)                               //power
```

```
    dissipated in transistor(W)
Pl=(Ve-Vbe)*Is-Vc*Il                    //power dissipated in LR
Vimax=(P+Vc*(Ic*10**-3))/(Ie*10**-3)    //input voltage maximum
Iomin=hfe*Ib1                           //output current minimum(mA)

//Results
printf ("power dissipated in the transistor is %.2f W and in LR is %.3f W",Pt/1E+3,Pl/1E+3)
printf ("maximum permissible input voltage is %.2f V",Vimax)
printf ("minimum load current for load voltage to remain stabalized is %.1f mA",Iomin)
```

Scilab code Exa 8.7 Example

```
//Variable declaration
VL=12               //load voltage(V)
I=2.                //current at 12 V
V=240               //dc source(V)
d=17/50.            //duty cycle
d1=0.6              //duty cycle
eta1=0.8            //efficiency
Vdc = 12
//Calculations
P=VL*I                          //average load power(W)
Isav=(1*d)/2                    //average supply current(A)
Pav=V*Isav                      //average supply power(W)
eta=(P/Pav)*100                 //regulator efficiency
Isav1=(1*d1)/2                  //average supply
```

```
current(A)
Il=(eta1*V*Isav1)/Vdc          //load current(A)
Po=Il*Vdc                      //power output(W)

//Results
printf("regulator efficiency is %.1f %%",eta)
printf("average supply current is %.1f A",Il)
printf("power output is %.1f W",Po)
```

Scilab code Exa 8.8 Example

```
//Variable declaration
Vs=200                    //dc source voltage(V)
Il=5                      //current to load voltage(A)
Vl=15                     //load voltage(V)
eta=.85                   //efficiency
f=20                      //oscillator frequency(Hz)
iSmax=2.6                 //peak value of supply current (A)
P=100                     //full load power supply(W)
pdf=0.4                   //pulse duty factor

//Calculations
Isav=(Vl*Il)/(Vs*eta)      //average peak supply current(A)
iS=(2*Isav)/pdf            //supply current(A)
T=1000/f                   //oscillation time period(uS)
tp=pdf*T                   //transistor time(us)
d=iS/tp                    //change in iS with respect to time(A/us)
tp1=iSmax/d                //transistor time(us)
pdf1=tp1/T                 //pulse duty factor
Isav1=(iSmax*pdf1)/2       //average peak supply current(A)
```

```
eta1=(P*100)/(Vs*Isav1) //efficiency

//Results
printf ("peak value of supply current is %.3f A",
   Isav)
printf ("pdf is %.3f ",pdf)
printf ("overall efficienc is %.1f %%",eta1)
```

Chapter 9

Integrated Circuit Fabrication

Scilab code Exa 9.2 Example

```
//Variable declaration
t=1                      //thickness(mil)
e=1.6*10**-19            //charge on electron(C)
Pp=10**17                //concentration of phosphorous
    (atoms/cm^3)
Bn=5*10**16              //boron concentration(atoms/cm
    ^3)
un=.135                  //mobility(m^2/Vs)

//Calculations
n=(Pp-Bn)*10**6          //net concentration(atoms/cm
    ^3)
g=e*un*n                 //conductivity()
rho=10**6/(g*25)         //resistivity(ohm mil)
Rs=rho/t                 //sheet resistance(ohm mil^2)

//Results
printf ("Sheet resistance is %.f ohm(mil**2)",Rs)
```

Scilab code Exa 9.3 Example

```
//Variable declaration
R=20*10**3                  //resistance of resistor(ohms)
w=25                        //width(um)
Rs=200                      //sheet resistance(ohm/square)
R1=5*10**3                  //resistance(ohms)

//Calculations
//Part a
l=(R*w)/Rs                  //length required to fabricate 20 kohms(um)

//Part b
L=25                 //length of resistor of 5 k ohms(um)
w1=(Rs*L)/R1         //width required to fabricate 5 kohms(um)

//Results
printf ("length required to fabricate 20 kohms resistor is %.1f um",l)
printf ("width required to fabricate 5 kohms resistor is %.1f um",w1)
```

Scilab code Exa 9.4 Example

```
//Variable declaration
C=0.4*10**-12                  //capacitance(pF/um^2)
A=10**-12                      //area of film(m^2)
d=400*10**-10                  //thickness of SiO2(amstrong)
Eo=8.849*10**-12               //absolute electrical
```

```
permitivity of free space

//Calculations
Er=(C*d)/(Eo*A)                   //relative dielectric
    constant

//Results
printf ("relative dielectric constant of SiO2 is %.f
    ",Er)
printf(" Note : Solution given in the textbook is
    incorrect")
```

Scilab code Exa 9.5 Example

```
//Variable declaration
C=250*10**-12                     //capacitance(pF)
d=500*10**-10                     //thickness of SiO2
    layer(amstrong)
Eo=8.849*10**-12                  //absolute electrical
    permitivity of free space
Er=3.5                            //relative dielectric
    constant

//Calculations
A=(C*d)/(Eo*Er)                 //chip area(um^2)

//Results
printf ("chip area needed for a 250 pF  MOS
    capacitor %.2f um^2",A/1e-7)
printf("Note: Solution given in the textbook is
    incorrect")
```

Chapter 10

Circuit Theory

Scilab code Exa 10.1 `Example`

```
//Variable declaration
i1=4.               //current through r1(A)
v3=3                //voltage(V)
v4=8                //voltage(V)
r3=3                //resistance(ohms)
r2=2                //resistance(ohms)
r4=4                //resistance(ohms)

//Calculations
i3=v3/r3                    //current through r3(A)
i4=v4/r4                    //current through r4(A)
i2=-(i3+i4-i1)/2            //current through r2(A)
v2=i2*r2                    //voltage through r2(V)

//Result
printf ("v2 is %.1f V",v2)
```

Scilab code Exa 10.2 `Example`

```
//Variable declaration
v1=6                    //current through r1(A)
i2=2                    //voltage through r3(V)
i3=4                    //voltage through r4(V)
r3=2                    //resistance(ohms)
v3=3                    //voltage through r3(ohms)
r2=2                    //resistance(ohms)
r4=3                    //resistance(ohms)

//Calculations
v2=i2*r2                     //voltage through r2(ohms)
v3=i3*r3                     //voltage through r3(ohms)
v4=4*i2+v3-v2-v1             //voltage through r4(ohms)
i4=v4/r4                     //current through r4(A)

//Result
printf ("i4 is %.f A",i4)
```

Scilab code Exa 10.3 Example

```

//Calculations
a = [7 -3 -4 ; -3 6 -2 ; -4 -2 11]  //solving three
   linear mesh equations
b = [-11;3;25]
x = a\b

v=x(3) - x(2)                                  //
   voltage across 2mho conductance(V)

//Results
printf ("v is %.1f V",v)
```

Scilab code Exa 10.4 Example

```
//Variable declaration
R=20                                //resistance across
    which voltage is to be calculated(ohms)

//Calculations
a = [35 -20 ; -20 50]    //solving two linear mesh
    equations
b = [50;-100]
x = a\b
i=x(1)-x(2)            //current through 20 ohms
    resistor(ohms)
V=20*i                 //voltage across 20 ohms(V)

//Results
printf ("i is %.2f",i)
printf ("voltage across 20 ohms is %.1f V",V)
```

Scilab code Exa 10.5 Example

```
//Variable declaration
Vs=16.                //source voltage(V)

//Calculations
//Part b
I=0                   //current through 10 V
Is=-4*(I-(Vs/32))     //current of current source(A)

//Part c
Is1=16                //current of current source(A)
I=0                   //current through 10 V
Vs1=(I+(Is1/4))*32    //source voltage(V)

```

```
//Results
printf ("Is is %.f A",Is)
printf ("Vs1 is %.f V",Vs1)
```

Scilab code Exa 10.6 Example

```
//Variable declaration
V=9                    //voltmeter of voltage(V)
i=9                    //ammeter current of 9V
r1=1                   //resistance(ohms)
r2=3                   //resistance(ohms)
r=5                    //resistance parallel to ammeter(ohms)

//Calculations
Isc=((i*r)-V)/(r1+r)        //short circuiting a and b and converting current source to a voltage source(A)
Ro=((r+r1)*r2)/((r+r1)+r2) //output resistance(ohms)

//Results
printf ("Isc is %.f A",Isc)
printf ("Ro is %.f ohms",Ro)
```

Scilab code Exa 10.7 Example

```

//Variable declaration
syms t            //symbol defined
et1 = complex(50,86.6)      //defining complex number

//calculations
```

```
et = (real(et1)*sqrt(2)*cos(314*t))+imag(et1)*sqrt(2)*cos(314*t+90)   //expression

//Result
disp ( et)
```

Scilab code Exa 10.9 Example

```

//Variable declarations
syms V1 V2


//Calculations
V = 0.3*V1                                                    //voltage(V)
I1 = 0.007*V1                                                 //current
y11 = I1/V1                                                   //y parameter

I2 = -V/40                                                    //current
y21 = I2/V1                                                   //y parameter

I2 = V2/(((40+100)*200.)/((40+100)+200.))                    //y parameter
y22 = I2/V2            //incorrect answer in textbook        //y parameter
```

```

I1 = (-I2*200)/300                                   //current
y12 = I1/V2          //incorrect answer in textbook //y parameter

//Results
disp ("mho" , y11+y12 ,"y11+y12 is")
disp ("mho" , y22+y12 ,"y22+y12 is")
disp ("mho" , y21-y12 ,"y21-y12 is")
disp ( "\n(The difference in answers is due to the y12 and y21 values calculated wrongly in the textbook)")
```

Scilab code Exa 10.10 `Example`

```
//Variable declaration

//port 2 open circuited ,port 1 excited
z11= complex(1075,1075)                    //as z11=V1/I1=(1.52<45)/(10**-3<0)=1075+1075j
z21 = complex(2022,-1075)                  //as z21=V2/I1=(2.29<-28)/(10**-3<0)=2022+1075j

//port 1 open circuited and port 2 excited
z12= complex(0,-1075)                      //as z12=V1/I2=(1.075<-90)/(10**3<0)=-1075j
z22= complex(751,-1073)                    //as z22=V2/I2=(1.31<-55)/(10**-3<0)=751-j1073

//Calculations
z=z11-z12                         //parameters with reference to circuit
z1=z22-z12
z2=z21-z12
```

```

//Results
printf ("z11-z12(z) is ")
disp(z)
printf ("z22-z12(z1) is")
disp(z1)
printf ("z21-z12(z2) is")
disp(z2)
```

Scilab code Exa 10.11 `Example`

```
//Variable declaration
V2=6/7.                           //voltage source(V)

//Calculations
Rth=V2                             //thevinin resistance(
   ohms)
Zl=Rth                             //load resistance(ohms)

//Result
printf ("load resistance is %.3f ohms",Zl)
```

Chapter 11

Cathode Ray Oscilloscope

Scilab code Exa 11.2 Example

```
//Variable declaration
E=120                   //electric field(V/m)
B=5*10**-5              //magnetic field(T)
q=1.6*10**-19           //charge on electron(C)
u=10**6                 //velocity of electron(m/s)
m=9.1*10**-31           //mass of electron(Kg)
a=9.81                  //acceleration of gravitation
   (m/s^2)

//Calculations
//Part a
fe=q*E                 //force on electron due to
   electric field(N)

//Part
fm=B*q*u              //force on electron due to
   magnetic field(N)

//Part c
fg=m*a                //force on electron due to
   gravitational field(N)
```

```

//Results
printf ("force on electron due to electric field is %.2e N",fe)
printf ("force on electron due to magnetic field is %.e N",fm)
printf ("force on electron due to gravitational field is %.4e N",fg)
```

Scilab code Exa 11.3 Example

```


//Variable declaration
T1=1200.                              //temperature(k)
T2=1000.                              //temperature(k)
Ww=1.2*10**5                          //work function(eV)
k=8.62
Ie1=200                              //emission current density
T3=1500.                             //temperature(k)

//Calculations
Ie2=Ie1*(T2/T1)**2*exp(-(Ww/k)*((1/T2)-(1/T1)))                //current density(mA/cm^2) at 1000k
Ie3=Ie1*(T3/T1)**2*exp(-(Ww/k)*((1/T3)-(1/T1)))                //current density(mA/cm^2) at 1000k

//Results
printf ("current density at 1000 k is %.2f mA/cm^2",Ie2)
printf ("current density at 1500 k is %.2f mA/cm^2",Ie3)
```

Scilab code Exa 11.4 Example

```


//Variable declaration
Ls=40                          //distance from screen(m)
d=1.5                          //distance between plates(cm)
Va=1200                        //accelerating potential(V)
L=3                            //length of CRT(m)
e=1.6*10**-19                  //charge on electron(C)
m=9.1*10**-31                  //mass of electron(Kg)
Y=4*10**-2                     //vertical deflection(V)

//Calculations
//Part a
U=sqrt((2*e*Va)/m)    //velocity of electron upon striking screen(m/s)

//Part
Vd=(2*d*Va*Y)/(L*Ls)        //deflecting voltage(V)

//Part c
Vdmax=(m*d**2*U**2)/(e*L**2)    //maximum allowable deflection(V)

//Results
printf ("velocity of electron upon stricking the screen is %.3e m/s",U)
printf ("deflecting voltage is %.f V",Vd/1E-2)
printf ("maximum allowable deflection is %.f V",Vdmax)
```