

Scilab Textbook Companion for
A Course In Mechanical Measurements And
Instrumentation
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May 23, 2016

¹Funded by a grant from the National Mission on Education through ICT, <http://spoken-tutorial.org/NMEICT-Intro>. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website <http://scilab.in>

Book Description

Title: A Course In Mechanical Measurements And Instrumentation

Author: A. K. Sawhney And P. Sawhney

Publisher: Dhanpat Rai, New Delhi

Edition: 12

Year: 2001

ISBN: 8177000233

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 2

Static Characteristics of Instruments and Measurement systems

Scilab code Exa 2.1 calculating static error and static correction

```
1 // calculating static error and static correction
2 clc;
3 disp('calculating static error and static correction
      ')
4 Am = 127.50;
5 At = 127.43;
6 e=Am-At;
7 disp(e, 'Static error (V)=');
8 Sc=-e;
9 disp(Sc, 'Static Correction (V)=');
```

Scilab code Exa 2.2 calculating true value of the temperature

```
1 // calculating true value of the temperature
```

```

2  clc;
3  disp('calculating true value of the temperature')
4  Am = 95.45;
5  Sc=-0.08;
6  At=Am+Sc;
7  disp(At, 'True Temperature(Degree C)=');

```

Scilab code Exa 2.3 calculating Relative error expressed as a percentage of f s d

```

1  // calculating Relative error (expressed as a
   // percentage of f.s.d)
2  clc;
3  disp('calculating Relative error (expressed as a
   // percentage of f.s.d)')
4  Am = 1.46;
5  At=1.50;
6  e=Am-At;
7  disp(e, 'Absolute error(V)=');
8  Sc=-e;
9  disp(Sc, 'Absolute Correction(V)=');
10 RE=(e/At)*100;
11 disp(RE, 'Relative Error in terms of true value(in
   // percentage)=');
12 REF=(e/2.5)*100;
13 disp(REF, 'Relative Error in terms of true value(in
   // percentage)=');

```

Scilab code Exa 2.4 calculating static error and static correction

```

1  // calculating static error and static correction
2  clc;

```

```

3 disp('calculating static error and static correction
      ')
4 Am = 0.000161;
5 At = 0.159*10^-3;
6 e=Am-At;
7 disp(e, 'Static error (m3/s)=');
8 Sc=-e;
9 disp(Sc, 'Static Correction (m3/s)=');

```

Scilab code Exa 2.5 calculating maximum static error Span of the thermometer degree C Accuracy of the thermometer in terms of percentage of span

```

1 //calculating maximum static error
2 disp('calculating maximum static error');
3 //Span of the thermometer(degree C)
4 S=200-150;
5 //Accuracy of the thermometer(in terms of percentage
  of span)
6 A=0.0025;
7 e= A*S;
8 disp(e, 'Maximum Static error (degree C)=');

```

Scilab code Exa 2.6 calculating the pressure for a dial reading of 100

```

1 // calculating the pressure for a dial reading of
  100
2 clc;
3 disp('calculating the pressure for a dial reading of
      100 ');
4 P=((27.58-6.895)/150)*100+6.895;
5

```

```
6 disp(P, 'pressure for a dial reading of 100(kN/m2)=')  
;
```

Scilab code Exa 2.7 calculating the noise output voltage of the amplifier

```
1 // calculating the noise output voltage of the  
  amplifier  
2 clc;  
3 disp('calculating the noise output voltage of the  
  amplifier')  
4 Bw=100*10^3;  
5 Sn=7*10^-21;  
6 R=50*10^3;  
7 A=(Sn*R*Bw)^0.5;  
8 En=2*A;  
9 disp(En, 'Noise voltage at input(V)=');  
10 Ga=100;  
11 Eno=En*Ga;  
12 disp(Eno, 'Noise voltage at output(V)=');
```

Scilab code Exa 2.8 calculating the noise voltage

```
1 // calculating the noise voltage  
2 clc;  
3 disp('calculating the noise voltage')  
4 Sn=20;  
5 Vs=3;  
6 Vn=Vs/(Sn)^0.5;  
7 disp(Vn, 'noise Voltage(mV)=')
```

Scilab code Exa 2.9 calculating the signal to noise ratio at input calculating the signal to noise ratio at output calculating the noise factor and noise figure

```
1 // calculating the signal to noise ratio at input
2 // calculating the signal to noise ratio at output
3 //calculating the noise factor and noise figure
4 clc;
5 disp('signal to noise ratio at input')
6 Sni=(3*10^-6/(1*10^-6))^2;
7 disp(Sni,'signal to noise ratio at input=')
8 disp('signal to noise ratio at output')
9 Sno=(60*10^-6/(20*10^-6))^2;
10 disp(Sno,'signal to noise ratio at output=')
11 disp('New signal to noise ratio at output')
12 Snno=(60*10^-6/(25*10^-6))^2;
13 disp(Snno,'signal to noise ratio at output=')
14 F=Sni/Snno;
15 disp(F,'noise Factor=')
16 nf=10*log10(F);
17 disp(nf,'noise Figure(dB)=')
```

Scilab code Exa 2.10 calculating the ratio of output signal to noise signal

```
1 // calculating the ratio of output signal to noise
   signal
2 clc;
3 disp('The noise voltage is')
4 Bw=100*10^3;
5 K=1.38*10^-23;
6 T=300;
7 R=120;
8 A=(K*T*R*Bw)^0.5;
9 En=2*A;
10 disp(En,'Noise voltage (V)=');
```

```

11 Eno=0.12*10^-3;
12 disp(Eno, 'Noise voltage at output(V)=');
13 Ra=Eno/En;
14 disp(Ra, 'Ratio of signal vottage to Noise voltage =')
    ;

```

Scilab code Exa 2.12 calculating the average force and range of error

```

1 //calculating the average force and range of error
2 clc;
3 F1=10.03;
4 F2=10.10;
5 F3=10.11;
6 F4=10.08;
7 Fav=(F1+F2+F3+F4)/4;
8 disp(Fav, 'Average Force (N) =');
9 Fmax=F3;
10 MaxR=Fmax-Fav;
11 Fmin=F1;
12 MinR=Fav-Fmin;
13 AvgR=(MaxR+MinR)/2;
14 disp(AvgR, 'Average range of error (N)=')

```

Scilab code Exa 2.13 calculating the sum of resistances connected in series with uncertainty of one unit

```

1 //calculating the sum of resistances connected in
    series with uncertainty of one unit
2 clc;
3 R1=72.3;
4 R2=2.73;
5 R3=0.612;
6 R=(R1+R2+R3);

```

```
7 disp(R, 'sum of resistances (ohm) =');
8
9 disp('the resultant resistance is 75.6 ohm with 6 as
    first doubtful figure')
```

Scilab code Exa 2.14 calculating the power with uncertainty of one unit in voltage and current

```
1 //calculating the power with uncertainty of one
    unit in voltage and current
2 clc;
3 V=12.16;
4 I=1.34;
5 P=V*I;
6 disp(P, 'Power (W) =');
7
8 disp('the resultant is 16.2 W with 2 as first
    doubtful figure')
```

Scilab code Exa 2.15 calculating the sum of resistances connected in series with appropriate number of significant figure

```
1 //calculating the sum of resistances connected in
    series with appropriate number of significant
    figure
2 clc;
3 R1=28.7;
4 R2=3.624;
5
6 R=(R1+R2);
7 disp(R, 'sum of resistances (ohm) =');
8
```

```
9 disp('the resultant resistance is 32.3 ohm as one of
      the resistance is accurate to three significant
      figure')
```

Scilab code Exa 2.16 calculating the voltage drop with appropriate number of significant figure

```
1 //calculating the voltage drop with appropriate
  number of significant figure
2 clc;
3 R=31.27;
4 I=4.37;
5
6 E=I*R;
7 disp(E, 'voltage drop(V) =');
8
9 disp('the voltage drop is 137 V as one of the
      resistance is accurate to three significant
      figure')
```

Scilab code Exa 2.17 calculating the sensitivity and deflection factor of wheatstone bridge

```
1 //calculating the sensitivity and deflection factor
  of wheatstone bridge
2 clc;
3 Mo=3;
4 Mi=7;
5 Sen=Mo/Mi;
6 disp(Sen, 'sensitivity (mm per ohm) =');
7 Df=Mi/Mo;
8 disp(Df, 'deflection factor( ohm per mm) =');
```

Scilab code Exa 2.18 calculating the volume of the mercury thermometer

```
1 //calculating the volume of the mercury thermometer
2 clc;
3 Ac=(%pi/4)*0.25^2;
4 disp(Ac,'Area of mercury thermometer')
5 Lc=13.8*10^3;
6 Vc=Ac*Lc;
7 disp(Vc,'Volume of mercury thermometer(mm3)')
```

Scilab code Exa 2.19 calculating the maximum position deviation resistance deviation

```
1 //calculating the maximum position deviation ,
   resistance deviation
2 clc;
3 P1=0.001;
4 FSD=320;
5 R=10000;
6 MDD=(P1*FSD);
7 disp(MDD,'Maximum displacement deviation(degree)');
8 MRD=P1*R;
9 disp(MRD,'Maximum displacement deviation(ohm)');
```

Scilab code Exa 2.20 calculating the dead zone

```
1 //calculating the dead zone
2 clc;
3 disp('span s=')
```

```
4 s=600;
5 Dz=0.00125*s;
6 disp(Dz, 'Dead zone (degree C)=');
```

Scilab code Exa 2.22 calculating the Resolution

```
1 //calculating the Resolution
2 clc;
3 Fs=200;
4 D=100;
5 SD=Fs/D;
6 R=SD/10;
7 disp(R, 'resolution (V)=')
```

Scilab code Exa 2.23 calculating the Resolution

```
1 //calculating the Resolution
2 clc;
3 Fs=9.999;
4 D=9999;
5 SD=Fs/D;
6 R=SD;
7 disp(R, 'resolution (V)=')
```

Scilab code Exa 2.24 calculating the reading of the multimeter and percentage error

```
1 //calculating the reading of the multimeter and
  percentage error
2 clc;
```

```

3 Z1=20000;
4 Zo=10000;
5 Eo=6;
6 E1=Eo/(1+Zo/Z1);
7 disp(E1,'Reading of the multimeter (V)=')
8 PE=((E1-Eo)/Eo)*100;
9 disp(PE,'Percentage error=')

```

Scilab code Exa 2.25 calculating the reading of the multimeter and percentage error

```

1 //calculating the reading of the multimeter and
   percentage error
2 clc;
3 Z1=20000;
4 Zo=1000;
5 Eo=6;
6 E1=Eo/(1+Zo/Z1);
7 disp(E1,'Reading of the multimeter (V)=')
8 PE=((E1-Eo)/Eo)*100;
9 disp(PE,'Percentage error=')

```

Scilab code Exa 2.26 calculating the loading error

```

1 //calculating the loading error
2 clc;
3 Z1=1000;
4 Zo=200*200/400;
5 Eo=100*200/400;
6 E1=Eo/(1+Zo/Z1);
7 disp(E1,'Reading of the multimeter (V)=')
8 PE=((E1-Eo)/Eo)*100;
9 disp(PE,'Percentage loading error=')

```

```
10 Ac=100+PE;
11 disp(Ac, 'Accuracy=')
```

Scilab code Exa 2.27 calculating the voltage across the oscilloscope

```
1 //calculating the voltage across the oscilloscope
2 clc;
3 C=50*10^-6;
4 f=100000;
5 disp(f, 'frequency=')
6 Xc=1/(2*pi*f*C);
7 R=10^6;
8 Zl=(R-%i*Xc)/(R-%i*Xc);
9 Eo=1;
10 Zo=10*10^3;
11
12 E1=Eo/(1+Zo/Zl);
13 disp(E1, 'Reading of the multimeter (V)=')
```

Scilab code Exa 2.28 calculating the actual value of current measured value of current and percentage error

```
1 //calculating the actual value of current, measured
   value of current and percentage error
2 clc;
3
4 Eo=10-((10*1000)/(1000+1000));
5 Zo=((1000*1000)/(1000+1000))+500;
6 Io=Eo/Zo;
7 disp(Io, 'Actual value of current (A)=')
8 Zl=100;
9 I1=Eo/(Zo+Zl);
10 disp(I1, 'Measured value of current (A)=')
```



```
11 PE=((I1-Io)/Io)*100;  
12 disp(PE, 'Percentage loading error=')
```

Scilab code Exa 2.29 calculating the maximum available power

```
1 //calculating the maximum available power  
2 clc;  
3  
4 Eo=80*10^-3;  
5 I1=5*10^-9;  
6 R1=6*10^6;  
7 Ro=(Eo/I1)-R1;  
8 Pmax=(Eo^2)/(4*Ro);  
9  
10 disp(Pmax, 'Maximum available Power (W)=')
```

Chapter 3

Errors in Measurements and Their Statistical Analysis

Scilab code Exa 3.1 calculating guarantee value of capacitance

```
1 // calculating guarantee value of capacitance
2 clc;
3 As = 1;
4 Er=0.05;
5 Aau=As*(1+Er);
6 disp(Aau, 'Upper limit (micro F)=');
7 Aal=As*(1-Er);
8 disp(Aal, 'Lower limit (micro F)=');
```

Scilab code Exa 3.2 calculating percentage limiting error

```
1 // calculating percentage limiting error
2 clc;
3 As = 150;
4 Er=0.01;
5 dA=As*Er;
```

```

6 As1=75;
7 Er=(dA/As1)*100;
8 disp(Er,'Percentage limiting error =');

```

Scilab code Exa 3.3 Calculate the range of readings

```

1 // Calculate the range of readings
2 clc;
3 fsd=1000;
4 TP=100;
5 Efsd=(1/100)*1000;
6 disp(Efsd,'magnitude of Error when specified in
      terms of full scale deflection (w)=')
7 disp('Thus the meter will read between 90W and 110W'
      )
8 Etv=(1/100)*100;
9 disp(Etv,'magnitude of Error when specified in terms
      of true value (w)=')
10 disp('Thus the meter will read between 99W and 101W'
      )

```

Scilab code Exa 3.4 Calculate the limiting error in percent

```

1 // Calculate the limiting error in percent
2 clc;
3 dA=0.05*5*10^-6;
4 As=2.5*10^-6;
5 Er=(dA/As)*100;
6 disp(Er,'percentge limiting error =+/-')

```

Scilab code Exa 3.5 Calculate the range of readings specified interms of fsd and true value

```
1 // Calculate the range of readings specified interms
   of f.s.d. and true value
2 clc;
3 disp('Range when specified interms of f.s.d.')
```

```
4 Error_fsd=1*1000/100'
5 Range_lower_value=100-Error_fsd;
6 disp(Range_lower_value,'Lower value of range (kN/m2)
   ')
7 Range_upper_value=100+Error_fsd;
8 disp(Range_upper_value,'Upper value of range (kN/m2)
   ')
9 disp('Range when specified interms of True value')
```

```
10 Error_true=1*100/100'
11 Range_lower_value=100-Error_true;
12 disp(Range_lower_value,'Lower value of range (kN/m2)
   ')
13 Range_upper_value=100+Error_true;
14 disp(Range_upper_value,'Upper value of range (kN/m2)
   ')
```

Scilab code Exa 3.6 Calculate the magnitude and limiting error in ohm and in percentage of the resistance

```
1 // Calculate the magnitude and limiting error in ohm
   and in percentage of the resistance
2 clc;
3 R1=37;
4 R1_le=5*R1/100;
5 R2=75;
6 R2_le=5*R2/100;
7 R3=50;
8 R3_le=5*R3/100;
```

```

9 R=R1+R2+R3;
10 disp(R,'Value of resistance (ohm)=')
11 R_le=R1_le+R2_le+R3_le;
12 disp(R_le,'Limiting Value of resistance (ohm)=')
13 Limiting_error_percentage=R_le*100/R;
14 disp(Limiting_error_percentage,'Limiting Value of
      resistance (percentage)=+/-')

```

Scilab code Exa 3.7 calculate the value of relative limiting error in resistance

```

1 // calculate the value of relative limiting error
  in resistance
2 clc;
3 Re_P=1.5;
4 Re_I=1;
5 Re_resistance=(Re_P+2*Re_I);
6 disp(Re_resistance,'the value of relative limiting
      error of resistance in percentage(+/-)=')

```

Scilab code Exa 3.8 Calculate the guaranteed values of the resistance

```

1 // Calculate the guaranteed values of the resistance
2 clc;
3 R1=100;
4 R1_le_perunit=0.5; // R1_le_perunit indicates dR1/R1
  = 0.5%
5 R2=1000;
6 R2_le_perunit=0.5;
7 R3=842;
8 R3_le_perunit=0.5;
9 Rx=R2*R3/R1;
10 disp(Rx,'Value of resistance (ohm)=')

```

```

11 Rx_le_perunit=R1_le_perunit+R2_le_perunit+
    R3_le_perunit;
12
13 disp(Rx_le_perunit,'Limiting Value of resistance per
    unit (dRx/Rx)=')
14 Er_Le=Rx_le_perunit*Rx/100;
15 disp(Er_Le,'Limiting Value of resistance (ohm)=+/-')
16 disp('Guarantee value of the resistance (ohm)=')
17 G1=Rx+Er_Le;
18 G2=Rx-Er_Le;
19 disp(G1,G2,'')

```

Scilab code Exa 3.9 Calculate the percentage limiting error and range of resistance values

```

1 // Calculate the percentage limiting error and range
    of resistance values
2 clc;
3 disp('decade a is set at 4000 ohm, so,error in
    decade a=')
4 Er_a=4000*0.1/100;
5 disp(Er_a)
6 disp('decade b is set at 600 ohm, so,error in decade
    b=')
7 Er_b=600*0.1/100;
8 disp(Er_b)
9 disp('decade c is set at 30 ohm, so,error in decade
    c=')
10 Er_c=30*0.1/100;
11 disp(Er_c)
12 disp('decade d is set at 9 ohm, so,error in decade d
    =')
13 Er_d=9*0.1/100;
14 disp(Er_d)
15 Er_total=Er_a+Er_b+Er_c+Er_d;

```

```

16 Re_le_percentage=Er_total*100/4639;
17 disp(Re_le_percentage,'Percentage Relative limiting
    error=')
18 Range_lower=4639-Er_total;
19 disp(Range_lower,'Lower value of range (ohm)=')
20 Range_upper=4639+Er_total;
21 disp(Range_upper,'upper value of range (ohm)=')

```

Scilab code Exa 3.10 Calculate the magnitude of power and limiting error

```

1 // Calculate the magnitude of power and limiting
  error
2 clc;
3 F=4.58;
4 L=397;
5 R=1202*10^-9;
6 t=60;
7 P=(2*pi*9.81*F*L*R)/(t*10^6);
8 disp(P,'Magnitude of power (W)=')
9 dF_pu=0.02/F; // per unit error in force
10 dL_pu=1.3/L; // per unit error in Length
11 dR_pu=1/R; // per unit error in revolution
12 dt_pu=0.5/t; // per unit error in time
13 dP_pu= dF_pu+dL_pu+dR_pu+dt_pu;
14 dP_le=dP_pu*P;
15 disp(dP_le,'Magnitude of limiting error in power (W)
    ')

```

Scilab code Exa 3.11 Calculate the magnitude of Force and limiting error

```

1 // Calculate the magnitude of Force and limiting
  error
2 clc;

```

```

3 E=200*10^9;
4 L=25*10^-3;
5 b=4.75*10^-3;
6 d=0.9*10^-3;
7 I=(b*d^3)/12;
8 x=2.5*10^-3;
9 F=(3*E*I*x)/(L^3);
10 disp(F, 'Magnitude of Force (N)=')
11 dE_pu=0/E; // per unit error in E
12 db_pu=0.0075/b;
13 dd_pu=0.0075/d;
14 dx_pu=0.025/x;
15 dL_pu=0.025/L;
16 dF_pu= (dE_pu+db_pu+3*dd_pu+dx_pu+3*dL_pu)*10^-3;
17
18 disp(dF_pu, 'limiting error in force (N)=+/-')

```

Scilab code Exa 3.12 calculate the power loss and relative error

```

1 // calculate the power loss and relative error
2 clc;
3 I=64*10^-3;
4 R=3200;
5 P=(I^2)*R;
6 disp(P, 'Power (W)=')
7 Re=2*0.75+0.2;
8 disp(Re, 'Relative error (%)=')

```

Scilab code Exa 3.13 Calculate the true power as a percentage of measured power

```

1 // Calculate the true power as a percentage of
   measured power

```



```

2  clc;
3  I=30.4;
4  R=0.015;
5  I_true=I*(1+0.012);
6  R_true=R*(1-0.003);
7  P_true=(I_true^2)*R_true;
8  P_measured=(I^2)*R;
9  R=P_true*100/P_measured;
10 disp(R, 'true power as a percentage of measured power
    (%)=' )

```

Scilab code Exa 3.14 calculate the total resistance error of each register and fractional error of total resistance

```

1  //calculate the total resistance , error of each
    register and fractional error of total resistance
2  clc;
3  R1=250;
4  R2=500;
5  R3=375;
6  R_true=1/((1/R1)+(1/R2)+(1/R3));
7  disp(R_true, 'True value of resistance (ohm)=')
8  dR1= 0.025*R1;
9  dR2=-0.36*R2;
10 dR3=0.014*R3;
11 R1_effective=R1+dR1;
12 R2_effective=R2+dR2;
13 R3_effective=R3+dR3;
14 R_effective=1/((1/R1_effective)+(1/R2_effective)+(1/
    R3_effective));
15 disp(R_effective, 'Effective value of resistance (ohm
    )=')
16 Fractional_error=(R_true-R_effective)/R_true;
17 disp(Fractional_error, 'Fractional_error ')

```

Scilab code Exa 3.15 find the error

```
1 //
2 clc;
3 disp('When all the components have 0% error then
      resonant frequency (Hz)')
4 L=160*10^-6;
5 C=160*10^-12;
6 fr=[1/(2*pi)]*[1/(L*C)]^0.5;
7 disp(fr)
8 disp('When all the components have +10% error then
      resonant frequency (Hz)')
9 L_new=(160*10^-6)+0.1*L;
10 C_new=(160*10^-12)+0.1*C;
11 fr_new=[1/(2*pi)]*[1/(L_new*C_new)]^0.5;
12 disp(fr_new)
13 error=(fr_new-fr)/fr;
14 disp(error, 'error=')
15 disp('When all the components have -10% error then
      resonant frequency (Hz)')
16 L_new=(160*10^-6)-0.1*L;
17 C_new=(160*10^-12)-0.1*C;
18 fr_new=[1/(2*pi)]*[1/(L_new*C_new)]^0.5;
19 disp(fr_new)
20 error=(fr_new-fr)/fr;
21 disp(error, 'error=')
```

Scilab code Exa 3.16 calculate the Volume and relative error

```
1 // calculate the Volume and relative error
2 clc;
3 L=250;
```

```

4 d=50;
5 V=((%pi/4)*d^2)*L;
6 disp(V, 'Volume(mm3)=')
7 Re=2*0.2-0.5;
8 disp(Re, 'Relative error (%)=')

```

Scilab code Exa 3.17 calculate the per unit change in the value of spring for different temperature ranges

```

1 // calculate the per unit change in the value of
   spring for different temperature ranges
2 clc;
3 dG_pu=-240*10^-6;
4 dD_pu=11.8*10^-6;
5 disp('for temperature change of 20 degree C to 50
   degree C (%) =')
6 d_th=30;
7 dK_pu=(dG_pu+dD_pu)*d_th*100;
8 disp(dK_pu)
9 disp('for temperature change of 20 degree C to -50
   degree C (%) =')
10 d_th=-70;
11 dK_pu=(dG_pu+dD_pu)*d_th*100;
12 disp(dK_pu)

```

Scilab code Exa 3.18 Calculate apparent resistance actual resistance and error

```

1 // Calculate apparent resistance , actual resistance
   and error
2 clc;
3 Et=100;
4 It=5*10^-3;

```

```

5 Rt=Et/It;
6 disp(Rt,'apparent value of resistance (ohm)=')
7 Rv=1000*150;
8 Rx=Rt*Rv/(Rv-Rt);
9 disp(Rx,'true value of resistance(ohm)')
10 Er_percentage=[(Rt-Rx)/Rx]*100;
11 disp(Er_percentage,'percentage error=')

```

Scilab code Exa 3.19 Calculate apparent resistance actual resistance and error

```

1 // Calculate apparent resistance , actual resistance
  and error
2 clc;
3 Et=40;
4 It=800*10^-3;
5 Rt=Et/It;
6 disp(Rt,'apparent value of resistance (ohm)=')
7 Rv=1000*150;
8 Rx=Rt*Rv/(Rv-Rt);
9 disp(Rx,'true value of resistance(ohm)')
10 Er_percentage=[(Rt-Rx)/Rx]*100;
11 disp(Er_percentage,'percentage error=')

```

Scilab code Exa 3.20 Calculate the error and percentage error in the measurement of deflection

```

1 //Calculate the error and percentage error in the
  measurement of deflection
2 clc;
3 l=0.2;
4 E=200*10^9;
5 b=20*10^-3;

```

```

6 d=5*10^-3;
7 D=(4*1^3)/(E*b*d^3);
8 F=1*9.81;
9 x_true= D*F;
10 disp(x_true,'True value of deflection')
11 x_indicated=D*10.31/(1+.1*D);
12 disp(x_indicated,'Indicated value of deflection')
13 Er=x_indicated-x_true;
14 disp(Er,'error=')
15 Er_percentage=Er*100/x_true;
16 disp(Er_percentage,'Percentage error=')

```

Scilab code Exa 3.21 to find the mean deviations from the mean Average deviation standard deviation and variance

```

1 //to find the mean, deviations from the mean, Average
   deviation , standard deviation and variance
2
3 clc;
4 x=[532 548 543 535 546 531 543 536];
5 X=sum(x);
6 n=8;
7 a=0;
8 Mean=X/n;
9 disp(X/n,'mean (kHz)');
10 for i=1:n,
11 d(i)=x(i)-Mean
12     disp(d(i),'deviations =')
13     a=a+(abs(d(i)))
14     end
15     d_average=a/n;
16 disp(d_average,'Average deviation (kHz)=')
17 d_2=sum(d^2);
18 s=sqrt(d_2/(n-1))
19 disp(s,'standard deviation (kHz)');

```

```

20 V=s^2;
21 disp(V, 'varaince (kHz)2=')

```

Scilab code Exa 3.22 to find the mean standard deviation probable error and range

```

1 //to find the mean, standard deviation , probable
  error and range
2
3 clc;
4 x=[41.7 42 41.8 42 42.1 41.9 42 41.9 42.5 41.8];
5 X=sum(x); disp(X);
6 d=[-.27 .03 -.17 .03 .13 -.07 .03 -.07 .53 -.17];
7 d_2=sum(d^2);
8 n=10;
9 disp(X/n, 'mean length(deg C)');
10 disp(sqrt(d_2/n), 'standard deviation(if data is
  infinite)(deg C)');
11 disp(sqrt(d_2/(n-1)), 'standard deviation(deg C)');
12 r1=.6745*sqrt(d_2/(n-1));
13 disp(r1, 'probable error of 1 reading(deg C)');
14 disp(r1/sqrt(n-1), 'probable error of mean(deg C)');
15 disp(max(x)-min(x), 'range(deg C)');

```

Scilab code Exa 3.23 to find the arithmetic mean maen deviation standard deviation probable error of 1 reading standard deviation and probable error of mean standard deviation of standard deviation

```

1 //to find the arithmetic mean, maen deviation ,
  standard deviation , prprobable error of 1 reading ,
  standard deviation and probable error of mean,
  standard deviation of standard deviation
2

```

```

3  clc;
4  T=[397 398 399 400 401 402 403 404 405];
5  f=[1 3 12 23 37 16 4 2 2];
6  Tf=sum(abs(T.*f));
7  disp(Tf/sum(f), 'mean temp(deg C)');
8  d=[-3.78 -2.78 -1.78 -.78 .22 1.22 2.22 3.22 4.22];
9  disp(sum(f.*d)/sum(f), 'mean deviation(deg C)');
10 disp(sqrt(sum(f.*d^2)/sum(f)), 'standard deviation (
    deg C)');
11 disp(.6745*sqrt(sum(f.*d^2)/sum(f)), 'probable error
    of 1 reading(deg C)');
12 disp((.6745*sqrt(sum(f.*d^2)/sum(f)))/sqrt(sum(f)), '
    probable error of mean(deg C)');
13 disp((sqrt(sum(f.*d^2)/sum(f)))/sqrt(sum(f)), '
    standard deviation of mean(deg C)');
14 disp((sqrt(sum(f.*d^2)/sum(f)))/sqrt(sum(f)*2), '
    standard deviation of standard deviation(deg C)')
    ;

```

Scilab code Exa 3.24 to find probable no of resistors

```

1  //to find probable no of resistors
2
3  clc;
4  x=.15;      //deviation
5  o=.1;      //standard deviation
6  t=x/o;
7  A=.4432    //area under gaussian curve corresponding
    to t
8  n=2*A*1000;
9  disp(floor(n), 'no of resistors');

```

Scilab code Exa 3.25 to find no of 100 rsding exceed 30mm

```

1 //to find no of 100 rsding exceed 30mm
2
3 clc;
4 x=30-26.3; //mean value 26.3
5 r=2.5;
6 o=r/.6745;
7 t=x/o;
8 A=.3413; //area under gaussian curve corresponding to
   t
9 n=2*A*100;
10 nn=100-floor(n);
11 disp(nn/2, 'no of readings exceed ');

```

Scilab code Exa 3.26 to find no of rods of desired length

```

1 //to find no of rods of desired length
2
3 clc;
4 n=25000; //no of rods
5 n1=12500; //length >10mm
6 n2=2000; //length >10.25
7 a=n1-n2; //10<length <10.25
8 p=a/n;
9 t=1.41; //using p
10 t1=t*2;
11 p1=.4975;
12 b=p1*n; //9.5<length <10
13 disp(a+floor(b), 'total no of rods ');

```

Scilab code Exa 3.27 to find standard deviation and probability of error

```

1 //to find standard deviation and probability of
   error

```



```

2
3 clc;
4 p=.2;
5 x=.8;
6 t=.5025;
7 sd=x/t;
8 disp(sd, 'standard deviation ');
9 x=1.2;
10 t=x/sd;
11 p=2*.2743;
12 disp(p, 'probability of error ');

```

Scilab code Exa 3.28 to find no of expected readings

```

1 //to find no of expected readings
2
3 clc;
4 x=20;
5 h=0.04;
6 sd=1/(sqrt(2)*h);
7 t=x/sd;
8
9 P=.3708;
10 disp(ceil(2*P*x), 'no of expected readings ');

```

Scilab code Exa 3.29 to calculate precision index of instrument

```

1 //to calculate precision index of instrument
2
3 clc;
4 t=.675;
5 x=2.4;
6 sd=x/t;

```

```

7 h=1/(sqrt(2)*sd);
8 disp(h, 'precision index');
9 t=(50-44)/sd;
10 p=.45;
11 n=8*30; //sept month no of measurements
12 a=((.5-p)*n);
13 disp(a, 'no of false alarms');
14
15 rn=a/2; //reduced no of false alarms
16 p1=rn/n;
17 P=.5-p1;
18 t=1.96;
19 sd=(50-44)/t;
20 h=1/(sqrt(2)*sd);
21 disp(h, 'precision index');

```

Scilab code Exa 3.30 to find confidence interval for given confidence levels

```

1 //to find confidence interval for given confidence
  levels
2
3 clc;
4 cl=[.5 .9 .95 .99];
5 s=.22;
6 d=[.7 1.83 2.26 3.25];
7 function [a]=ci(b)
8     a=s*b;
9 endfunction
10
11 CI(1)=ci(d(1));
12 CI(2)=ci(d(2));
13 CI(3)=ci(d(3));
14 CI(4)=ci(d(4));
15
16 disp(CI, 'confidence interval');

```

Scilab code Exa 3.31 to point out the reading that can be rejected by chavenets criterion

```
1 //to point out the reading that can be rejected by
   chavenets criterion
2
3 clc;
4 x=[5.3 5.73 6.77 5.26 4.33 5.45 6.09 5.64 5.81
   5.75]*10^-3;
5 d=[-.313 .117 1.157 -.353 -1.283 -.163 .477 .027
   .197 .137]*10^-3;
6 n=10;
7 X=sum(x)/n;
8 s=sqrt(sum(d^2)/(n-1));
9 a=abs(d)/s;disp(a);
10
11
12 for i=1:10,
13
14 if a(i)>1.96 then
15     disp(x(i),'rejected value');
16 end
17 end
```

Scilab code Exa 3.32 calculate standard deviation

```
1 //calculate standard deviation
2
3 clc;
4 x=[.9 2.3 3.3 4.5 5.7 6.7];
5 y=[1.1 1.6 2.6 3.2 4 5];
```

```

6 n=6;
7 a=((n*sum(x.*y)-(sum(x)*sum(y)))/((sum(x^2)*n)-sum(x
    )^2));
8 b=((sum(y)*sum(x^2)-(sum(x)*sum(x.*y)))/((sum(x^2)*n
    )-sum(x)^2));
9
10 sdy=sqrt((1/n)*sum((a*x+b-y)^2));
11 sdx=sdy/a;
12
13 sa=sqrt(n/(n*sum(x^2)-sum(x)^2))*sdy;
14 sb=sqrt(sum(x^2)/(n*sum(x^2)-sum(x)^2))*sdy;
15 disp(sa, 's_a ');
16 disp(sb, 's_b ');

```

Scilab code Exa 3.34 determine value of total current considering errors as limiting errors and as standard deviations

```

1 //determine value of total current considering
   errors as limiting errors and as standard
   deviations
2
3 clc;
4 I1=200;
5 I2=100;
6 dI1=2;
7 dI2=5;
8 I=I1+I2;
9 dI=((I1/I)*(dI1/I1)+(I2/I)*(dI2/I2));
10 disp('error considered as limiting errors');
11 disp(I, 'I');
12 disp(dI*I, 'dI');
13 sdI=sqrt(dI1^2+dI2^2);
14 disp('error considered as standard deviations');
15 disp(I, 'I');
16 disp(sdI, 'sdI');

```

Scilab code Exa 3.35 determine probable error in the computed value of resistnce

```
1 //determine probable error in the computed value of
   resistnce
2
3 clc;
4 r_V=12;
5 I=10;
6 r_Rv=r_V/I;
7 V=100;
8 r1=2;
9 r_Ri=V*r1/I^2;
10 r_R=sqrt(r_Rv^2+r_Ri^2);
11 disp(r_R, 'r_R');
```

Scilab code Exa 3.37 to find Cq and its possible errors

```
1 //to find Cq and its possible errors
2
3 clc;
4 d=12.5;
5 A=(%pi/4)*d^2*10^-6;
6 W=392;
7 t=600;
8 p=1000;
9 g=9.81;
10 h=3.66;
11 Cq=W/(t*p*A*sqrt(2*g*h));
12 disp(Cq, 'Cq');
13 dW=.23/W;
```

```

14 dt=2/t;
15 dp=.1/100;
16 dA=2*.002;
17 dg=.1/100;
18 dh=.003/h;
19 dd=.002;
20 dCq=Cq*(dW+dt+dp+dA+dg/2+dh/2);
21 disp(dCq*100/Cq, '%age absolute error ');
22
23 sdCq=Cq*sqrt(dW^2+dt^2+dp^2+4*dd^2+.25*(dg^2+dh^2));
24 disp(sdCq*100/Cq, '%age standard deviation error ');

```

Scilab code Exa 3.38 calculate power disipated and uncertaainity in power

```

1 //calculate power disipated and uncertaainity in
  power
2
3 clc;
4 V=110.2;
5 I=5.3;
6 P=V*I; disp(P, 'power (W) dissipated ');
7 w_v=.2;
8 w_i=0.06;
9 dp=sqrt((w_v*I)^2+(w_i*V)^2);
10 disp(dp*100/P, 'uncertainty in power (%) ');

```

Scilab code Exa 3.39 to find uncertainty in combined resistance in both series and in parrallel

```

1 //to find uncertainty in combined resistance in
  both series and in parrallel
2
3 clc;

```

```

4 R1=100;
5 R2=50;
6 wR1=.1;
7 wR2=0.03;
8 disp('series conn');
9 R=R1+R2;disp(R,'resistance (ohm)');
10 dR1=1;
11 dR2=1;
12 wR=sqrt((dR1*wR1)^2+(dR2*wR2)^2);disp(wR,'
    uncertainty in resistance (ohm)');
13
14 disp('parrallel conn');
15 R=R1*R2*(R1+R2)^-1;disp(R,'resistance (ohm)');
16 dR1=(R2/(R1+R2))-((R1*R2)/(R1+R2)^2);
17 dR2=(R1/(R1+R2))-((R1*R2)/(R1+R2)^2);
18 wR=sqrt((dR1*wR1)^2+(dR2*wR2)^2);disp(wR,'
    uncertainty in resistance (ohm)');

```

Scilab code Exa 3.40 to calculate uncertainty in measurement

```

1 //to calculate uncertainty in measurement
2
3 clc;
4 l=150;
5 dl=0.01;
6 b=50;
7 wA=l*dl;
8 disp('when no uncertainty in measurement of length'
    );
9 disp(wA,'uncertainty in measurement of area(m*m)');
10
11 disp('when no certainty in measurement of length');
12 wA=1.5*1.5;
13 wB=0.01;
14 wL=sqrt((wA^2-(1*wB)^2)/b^2);

```

```
15 disp(wL, 'uncertainty in measurement of length(m)');
```

Scilab code Exa 3.41 to calculate uncertainty in power

```
1 //to calculate uncertainty in power
2
3 clc;
4 E=100;
5 dE=.01;
6 I=10;
7 dI=0.01;
8 R=10;
9 dR=.01;
10 dP=sqrt(4*dE^2+dR^2)*100; //P=E^2/R
11 disp(dP, '%age uncertainty in power measurement');
12
13 dP=sqrt(dE^2+dI^2)*100; //P=E*I
14 disp(dP, '%age uncertainty in power measurement');
```

Chapter 4

Dynamic Characteristics of Instruments and Measurement systems

Scilab code Exa 4.1 calculating the temperature

```
1 // calculating the temperature after 1.5 s
2 clc;
3 th0=100;
4 t=1.5;
5 tc=3.5;
6 th=th0*[1-exp(-t/tc)];
7 disp(th,'temperature after 1.5 s (degree C)')
```

Scilab code Exa 4.2 calculate time to read half of the temperature difference

```
1 // calculate time to read half of the temperature
  difference
2 clc;
```

```
3 tc=10/5;
4 th=1;
5 th0=2;
6 t=-tc*log(1-(th/th0));
7 disp(t,'Time to read half of the temperature
   difference (s)')
```

Scilab code Exa 4.4 Calculate the temperature after 10s

```
1 // Calculate the temperature after 10s
2 clc;
3 th0=25;
4 thi=150;
5 t=10;
6 tc=6;
7 th=th0+(thi-th0)*[exp(-t/tc)];
8 disp(th,'the temperature after 10s (degree C)')
```

Scilab code Exa 4.5 Calculate the value of resistance after 15s

```
1 // Calculate the value of resistance after 15s
2 clc;
3 R0=29.44;
4 Rs=100;
5 t=15;
6 tc=5.5;
7 R_15=Rs+R0*[1-exp(-t/tc)];
8 disp(R_15,'value of resistance after 15s(ohm)')
```

Scilab code Exa 4.6 Calculate the depth after one hour

```

1 // Calculate the depth after one hour
2 clc;
3 Qm=0.16*10^-3;
4 Hin=1.2;
5 K1=Qm/(Hin)^0.5;
6 Qo=0.2*10^-3;
7 Ho=(Qo/K1)^2;
8 R=Hin/Qm;
9 C=0.1;
10 tc=R*C;
11 t=3600;
12 H=Ho+(Hin-Ho)*exp(-t/tc);
13 disp(H, 'the depth after one hour(m)')

```

Scilab code Exa 4.8 Calculate time constant

```

1 // Calculate time constant
2 clc;
3 S=3.5;
4 Ac=(%pi/4)*(0.25)^2;
5 alpha=0.18*10^-3;
6 Vb=S*Ac/alpha;
7 disp(Vb, 'volume of bulb(mm2)')
8
9 Rb=[(Vb/%pi)*(3/4)]^(1/3);
10 Ab=4*%pi*Rb^2;
11 D=13.56*10^3;
12 s=139;
13 H=12;
14 tc=(D*s*Vb*10^-9)/(H*Ab*10^-6);
15 disp(tc, 'time constant (s)')

```

Scilab code Exa 4.9 Calculate the temperature after 10s

```

1 // Calculate the time constant
2 ess=5;
3 A=0.1;
4 tc=ess/A;
5 disp(tc,'time constant(s)')

```

Scilab code Exa 4.10 Calculate the temperature at a depth of 1000 m

```

1 // Calculate the temperature at a depth of 1000 m
2 clc;
3 th0=20;
4 t=2000;
5 thr=th0-0.005*(t-50)-0.25*exp(-t/50);
6 disp(thr,'temperature at a depth of 1000 m (degree C
)')

```

Scilab code Exa 4.11 Calculate the value of resistance at different values of time

```

1 // Calculate the value of resistance at different
   values of time
2 clc;
3 Gain=0.3925;
4 T=75;
5 p_duration=Gain*T;
6 tc=5.5;
7 Rin=100;
8 t=1;
9 Rt=p_duration*(1-exp(-t/tc))+Rin;
10 disp(Rt,'Value of resistance after 1s(ohm)=')
11 t=2;
12 Rt=p_duration*(1-exp(-t/tc))+Rin;
13 disp(Rt,'Value of resistance after 2s(ohm)=')

```

```

14 t=3;
15 Rt=p_duration*(1-exp(-t/tc))+Rin;
16 disp(Rt,'Value of resistance after 3s(ohm)=')
17 R_inc=Rt-Rin;
18 t=5;
19 Rt=(R_inc)*[exp(-(t-3)/(5.5))]+Rin;
20 disp(Rt,'Value of resistance after 5s(ohm)=')
21 t=10;
22 Rt=(R_inc)*[exp(-(t-3)/(5.5))]+Rin;
23 disp(Rt,'Value of resistance after 10s(ohm)=')
24 t=20;
25 Rt=(R_inc)*[exp(-(t-3)/(5.5))]+Rin;
26 disp(Rt,'Value of resistance after 20s(ohm)=')
27 t=30;
28 Rt=(R_inc)*[exp(-(t-3)/(5.5))]+Rin;
29 disp(Rt,'Value of resistance after 30s(ohm)=')

```

Scilab code Exa 4.12 calculate the value of damping constant and frequency of damped oscillations

```

1 // calculate the value of damping constant and
   frequency of damped oscillations
2 clc;
3 M=8*10^-3;
4 K=1000;
5 wn=(K/M)^0.5;
6 disp('for critically damped system eta=1')
7 B=2*(K*M);
8 disp(B,'Damping constant for critically damped
   system (N/ms-1)=')
9 eta=0.6;
10 wd=wn*(1-eta^2)^0.5;
11 disp(wd,'frequency of damped oscillations (rad/s)=')

```

Scilab code Exa 4.13 Calculate damping ratio natural frequency frequency of damped oscillations time constant and steady state error for ramp signal

```
1 // Calculate damping ratio , natural frequency ,
   frequency of damped oscillations , time constant
2 // and steady state error for ramp signal of 5V/s
3 clc;
4 K=(40*10^-6)/(%pi/2);
5 J=0.5*10^-6;
6 B=5*10^-6;
7 eta=B/(2*(K*J)^0.5);
8 disp(eta, 'damping ratio=')
9 wn=(K/J)^0.5;
10 disp(wn, 'natural frequency (rad/sec)')
11 wd=wn*(1-(eta)^2)^0.5;
12 disp(wd, 'frequency of damped oscillations (rad/s)')
13 tc=1/wn;
14 disp(tc, 'time constant (s)')
15 ess=2*eta/wn;
16 disp('for a ramp input of 5V, steady state error (V)
   =')
17 ess=5*2*eta/wn;
18 disp(ess, '')
19 T_lag=2*eta*tc;
20 disp(T_lag, 'Time lag (s)')
```

Scilab code Exa 4.14 Calculate the natural frequency

```
1 // Calculate the natural frequency
2 clc;
3 wn=2*%pi*30;
```

```

4 disp( 'for a frequency of 30 Hz  wn=(K/M+5*10^-3)
      ^ 0.5.....( i) ');
5 disp( 'But wn=(K/M) ^ 0.5.....( ii) ');
6 disp('for a frequency of 25 Hz  wn=(K/M
      +5*10^-3+5*10^-3) ^ 0.5.....( iii) ')
7 disp('on solving (i), (ii) and (iii)')
8 M=6.36*10^-3;
9 K=403.6;
10 disp(M, 'M=')
11 disp(K, 'K=')
12 wn=(K/M)^0.5;
13 f=wn/(2*%pi);
14 disp(f, 'natural frequency (Hz)')

```

Scilab code Exa 4.15 Calculate natural frequency and settling time

```

1 // Calculate natural frequency and settling time
2 clc;
3 K=60*10^3;
4 M=30;
5 wn=(K/M)^0.5;
6 disp(wn, 'natural frequency (rad/sec)')
7 eta=0.7;
8 ts=4/(eta*wn);
9 disp(ts, 'settling time (s)')

```

Scilab code Exa 4.16 Calculate time lag and ratio of output and input

```

1 // Calculate time lag and ratio of output and input
2 clc;
3 disp('when time period is 600s')
4 w=2*%pi/600;
5 tc=60;

```

```

6 T_lag=(1/w)*atan(w*tc);
7 disp(T_lag,'time lag (s)=')
8 M=1/((1+(w*tc)^2)^0.5);
9 disp(M,'ratio of output and input=')
10 disp('when time period is 120s')
11 w=2*pi/120;
12 tc=60;
13 T_lag=(1/w)*atan(w*tc);
14 disp(T_lag,'time lag (s)=')
15 M=1/((1+(w*tc)^2)^0.5);
16 disp(M,'ratio of output and input=')

```

Scilab code Exa 4.17 Calculate the maximum allowable time constant and phase shift

```

1 // Calculate the maximum allowable time constant and
   phase shift
2 clc;
3 M=1-0.05;
4 w=2*pi*100;
5 tc={[(1/M^2)-1]/(w^2)}^0.5;
6 disp(tc,'maximum allowable time constant (s)')
7 disp('phase shift at 50 Hz (degree)=')
8 ph=[-atan(2*pi*50*tc)]*(180/pi);
9 disp(ph,'')
10 disp('phase shift at 100 Hz (degree)=')
11 ph=[-atan(2*pi*100*tc)]*(180/pi);
12 disp(ph,)

```

Scilab code Exa 4.18 Calculate maximum value of indicated temperature and delay time


```

1 // Calculate maximum value of indicated temperature
  and delay time
2 clc;
3 T=120;
4 w=2*%pi/T;
5 tc1=40;
6 tc2=20;
7 M=[1/((1+(w*tc1)^2)^0.5)]*[1/((1+(w*tc2)^2)^0.5)];
8 M_temp=M*10;
9 disp(M_temp,'maximum value of indicated temperature
  (degree C)');
10 ph=[atan(w*tc1)+atan(w*tc2)];
11 T_lag=ph/w;
12 disp(T_lag,'Time lag (s)')

```

Scilab code Exa 4.19 Find the output

```

1 // Find the output
2 clc;
3 disp('when tc=0.2);
4 disp('output=1/(1+(2*0.2)^2)^0.5 sin[2t-atan(2*0.2)
  ]+3/(1+(2*0.2)^2)^0.5 sin[20t-atan(20*0.2)]')
5 disp('on solving output=0.93 sin(2t-21.8)+0.073
  sin(20t-76)')
6 disp('when tc=0.002);
7 disp('output=1/(1+(2*0.002)^2)^0.5 sin[2t-atan
  (2*0.002)]+3/(1+(2*0.002)^2)^0.5 sin[20t-atan
  (20*0.002)]')
8 disp('on solving output= 1sin(2t-0.23)+0.3 sin(20t
  -2.3)')

```

Scilab code Exa 4.20 Calculate maximum and minimum value of indicated temperature phase shift time lag

```

1 //Calculate maximum and minimum value of indicated
  temperature, phase shift, time lag
2 clc;
3 T_max=640;
4 T_min=600;
5 T_mean=(T_max+T_min)/2;
6 Ai=T_mean-T_min;
7 w=2*%pi/80;
8 tc=10;
9 Ao=Ai/{(1+(w*tc)^2)}^0.5;
10 T_max_indicated=T_mean+Ao;
11 disp(T_max_indicated,'Maximum value of indicated
  temperature (degree C)=')
12 T_min_indicated=T_mean-Ao;
13 disp(T_min_indicated,'Minimum value of indicated
  temperature (degree C)=')
14 ph=-atan(w*tc);
15 Time_lag=-ph/w;
16 disp(Time_lag,'Time lag (s)')
```

Scilab code Exa 4.21 determine damping ratio

```

1 // determine damping ratio
2 clc;
3 w=2;
4 K=1.5;
5 J=200*10^-3;
6 wn=(K/J)^0.5;
7 u=w/wn;
8 M=1.1;
9 eta=[{[1/(M^2)]-[(1-u^2)^2]}/(2*u)^2]^0.5;
10 disp(eta,'damping ratio=')
```

Scilab code Exa 4.22 Calculate the frequency range

```
1 // Calculate the frequency range
2 clc;
3 eta=0.6;
4 fn=1000;
5 M=1.1;
6 disp('M=1/[[ $(1-u^2)^2$ ]+ $(2*u*eta)^2$ ]0.5; ..... (
    i)')
7 disp('on solving  $u^4-0.5u^2+0.173=0$ ')
8 disp('the above equation gives imaginary values for
    frequency so for eta=0.6 the output is not 1.1')
9 disp('Now let M=0.9, on solving equation (i) we have
    ')
10 disp('u4-0.56u2-0.234=0')
11 disp('on solving u=0.916')
12 u=0.916;
13 f=u*fn;
14 disp(f,'maximum value of range (Hz)=')
15 disp('So, the range of the frequency is from 0 to
    916 Hz')
```

Scilab code Exa 4.23 determine the error

```
1 // determine the error
2 clc;
3 w=6;
4 wn=4;
5 u=w/wn;
6 eta=0.66;
7 M=1/{ $[(1-u^2)^2+(2*eta*u)^2]$ 0.5};
8 Error=(M-1)*100;
9 disp(Error,'error (%)=')
```

Chapter 5

Primary Sensing Elements and Transducers

Scilab code Exa 5.1 Calculate the deflection at center

```
1 // Calculate the deflection at center
2 clc;
3 D=15*10^-3;
4 P=300*10^3;
5 sm=300*10^6;
6 t=[3*D^2*P/(16*sm)]^0.5;
7 disp(t, ' thickness (m)=')
8 P=150*10^3;
9 v=0.28;
10 E=200*10^9;
11 dm=3*(1-v^2)*D^4*P/(256*E*t^3);
12 disp(dm, ' deflection at center for Pressure of 150
    kN/m2(m)=')
```

Scilab code Exa 5.2 Calculate the angle of twist

```

1 // Calculate the angle of twist
2 clc;
3 T=100;
4 G=80*109;
5 d=2*15*10-3;
6 th=16*T/(%pi*G*d3)
7 disp(th, ' angle of twist(rad)=')
```

Scilab code Exa 5.3 Calculate the Torque

```

1 // Calculate the Torque
2 clc;
3
4 E=110*109;
5 t=0.073*10-3;
6 b=0.51*10-3;
7 l=370*10-3;
8 th=%pi/2;
9 T=(E*b*t3)*th/(12*l);
10 disp(T, ' Controlling torque(Nm)=')
```

Scilab code Exa 5.4 Calculating the displacement and resolution of the potentiometer

```

1 //Calculating the displacement and resolution of the
  potentiometer
2 clc;
3 Rnormal=10000/2;
4 Rp1=10000/50;
5 Rc1=Rnormal-3850;
6 Dnormal=Rc1/Rp1;
7 disp(Dnormal, ' Displacement (mm)=')
8 Rc2=Rnormal-7560;
```

```

9 Dnormal=Rc2/Rp1;
10 disp(Dnormal, 'Displacement (mm)=')
11 disp('since one displacement is positive and other
      is negative so two displacements are in the
      opposite direction ')
12 Re=10*1/200;
13 disp(Re, 'Resolution (mm)=')

```

Scilab code Exa 5.5 plot the graph of error versus K

```

1 // plot the graph of error versus K
2 clc;
3 K=[0    0.25    0.5    0.75    1];
4 V=[0    -0.174    -0.454    -0.524    0];
5 plot(K,V)

```

Scilab code Exa 5.6 Calculating the output voltage

```

1 //Calculating the output voltage
2 clc;
3 RAB=125;
4 Rtotal=5000;
5 R2=75/125*Rtotal;
6 R4=2500;
7 ei=5;
8 eo=[(R2/Rtotal)-(R4/Rtotal)]*ei;
9 disp(eo, 'output voltage (V)=')

```

Scilab code Exa 5.7 Calculating the maximum excitation voltage and the sensitivity

```

1 // Calculating the maximum excitation voltage and
   the sensitivity
2 clc;
3 Rm=10000;
4 Rp=Rm/15;
5 R=600;
6 P=5;
7 ei= (P*R)^0.5;
8 disp(ei, 'Maximum excitation voltage (V)=')
9 S=ei/360;
10 disp(S, 'Sensitivity (V/degree)=')
```

Scilab code Exa 5.8 Calculating the resolution of the potentiometer

```

1 // Calculating the resolution of the potentiometer
2 clc;
3 Rwga=1/400;
4 Re=Rwga/5;
5 disp(Re, 'Resolution (mm)=')
```

Scilab code Exa 5.9 Checking the suitability of the potentiometer

```

1 // Checking the suitability of the potentiometer
2 clc;
3 mo=0.8;
4 sr=250;
5 sm=sr/mo;
6 R=sm*1;
7 disp(R, 'resolution of 1mm movement')
8 Rq=300/1000;
9 disp(Rq, 'resolution required=')
```

```
10 disp('since the resolution of potentiometer is
    higher than the resolution required so it is
    suitable for the application')
```

Scilab code Exa 5.10 Checking the suitability of the potentiometer

```
1 // Checking the suitability of the potentiometer
2 clc;
3 Pd=(10^2)/150;
4 disp(Pd,'Power dissipation (W)=')
5 th_pot=80+Pd*30*10^-3;
6 PDa=1-(10*10^-3)*(th_pot-35);
7 disp(PDa,'Power dissipation allowed (W)=')
8 disp('Since power dissipation is higher than the
    dissipation allowed so potentiometer is not
    suitable')
```

Scilab code Exa 5.11 Calculating the possion ratio

```
1 // Calculating the possion 's ratio
2 clc;
3 Gf=4.2;
4 v=(Gf-1)/2;
5 disp(v,'Possion s ratio=')
```

Scilab code Exa 5.12 Calculating the value of the resistance of the gauges

```
1 // Calculating the value of the resistance of the
    gauges
2 clc;
```



```

3 strain=-5*10^-6;
4 Gf=-12.1;
5 R=120;
6 dR_nickel=Gf*R*strain;
7 disp(dR_nickel,'change in resistance of nickel(ohm)=
      ')
8 Gf=2;
9 R=120;
10 dR_nicrome=Gf*R*strain;
11 disp(dR_nicrome,'change in resistance of nicrome(ohm
      )=')

```

Scilab code Exa 5.13 calculate the percentage change in value of the gauge resistance

```

1 // calculate the percentage change in value of the
   gauge resistance
2 clc;
3 s=100*10^6;
4 E=200*10^9;
5 strain=s/E;
6 Gf=2;
7 r_perunit=Gf*strain*100;
8 disp(r_perunit,'Percentage change in resistance=')

```

Scilab code Exa 5.14 Calculating the Gauge factor

```

1 //Calculating the Gauge factor
2 clc;
3 b=0.02;
4 d=0.003;
5 I=(b*d^3)/12;
6 E=200*10^9;

```

```

7 x=12.7*10^-3;
8 l=0.25;
9 F=3*E*I*x/l^3;
10 x=0.15;
11 M=F*x;
12 t=0.003;
13 s=(M*t)/(I*2);
14 strain=s/E;
15 dR=0.152;
16 R=120;
17 Gf=(dR/R)/strain;
18 disp(Gf, 'Gauge factor=')

```

Scilab code Exa 5.15 Calculating the change in length and the force applied

```

1 // Calculating the change in length and the force
  applied
2 clc;
3 dR=0.013;
4 R=240;
5 l=0.1;
6 Gf=2.2;
7 dl=(dR/R)*l/Gf;
8 disp(dl, 'change in length (m)=')
9 strain=dl/l;
10 E=207*10^9;
11 s=E*strain;
12 A=4*10^-4;
13 F=s*A;
14 disp(F, 'Force (N) ')

```

Scilab code Exa 5.16 Calculate the linear approximation

```

1 // Calculate the linear approximation
2 clc;
3 th1=30;
4 th2=60;
5 th0=(th1+th2)/2;
6 Rth1=4.8;
7 Rth2=6.2;
8 Rth0=5.5;
9 ath0=(1/Rth0)*(Rth2-Rth1)/(th2-th1);
10 disp(ath0,'alpha at 0 degree(/degree C)=')
11 disp('5.5[1+0.0085(th-45)]')

```

Scilab code Exa 5.17 Calculate the linear approximation

```

1 // Calculate the linear approximation
2 clc;
3 th1=100;
4 th2=130;
5 th0=(th1+th2)/2;
6 Rth1=573.40;
7 Rth2=605.52;
8 Rth0=589.48;
9 ath0=(1/Rth0)*(Rth2-Rth1)/(th2-th1);
10 disp(ath0,'alpha at 0 degree(/degree C)=')
11 disp('Linear approximation is: Rth=
    589.48[1+0.00182(th-115)]')

```

Scilab code Exa 5.18 Calculate the resistance and the temperature

```

1 // Calculate the resistance and the temperature
2 clc;
3 Rth0=100;
4 ath0=0.00392;

```

```
5 dth=65-25;
6 R65=Rth0*[1+ath0*dth];
7 disp(R65,'resistance at 65 degree C(ohm)=')
8
9 th={[(150/100)-1]/ath0}+25;
10 disp(th,'Temperature (degree C)')
```

Scilab code Exa 5.19 Calculate the resistance

```
1 // Calculate the resistance
2 clc;
3 Rth0=10;
4 ath0=0.00393;
5 dth=150-20;
6 R150=Rth0*[1+ath0*dth];
7 disp(R150,'resistance at 150 degree C(ohm)=')
```

Scilab code Exa 5.20 Calculate the time

```
1 // Calculate the time
2 clc;
3 th=30;
4 th0=50;
5 tc=120;
6 t=-120*[log(1-(th/th0))];
7 disp(t,'time(s)')
```

Scilab code Exa 5.21 Calculate the resistance

```
1 // Calculate the resistance
```

```

2  clc;
3  R25=100;
4  ath=-0.05;
5  dth=35-25;
6  R35=R25*[1+ath*dth];
7  disp(R35, 'resistance at 35 degree C(ohm)=')

```

Scilab code Exa 5.22 find resistance

```

1  //
2  clc;
3  Ro=3980;
4  Ta=273;
5  disp('3980= a*3980*exp(b/273)')
6  Rt50=794;
7  Ta50=273+50;
8  disp('794= a*3980*exp(b/323)')
9  disp('on solving')
10 disp('a=30*10^-6', 'b=2843')
11 Ta40=273+40;
12 Rt40=(30*10^-6)*3980*exp(2843/313);
13 disp(Rt40, 'Resistance at 40 degree C (ohm)')
14 Rt100=(30*10^-6)*3980*exp(2843/373);
15 disp(Rt100, 'Resistance at 100 degree C (ohm)')

```

Scilab code Exa 5.23 calculating the change in temperature

```

1  // calculating the change in temperature
2  clc;
3  th=((1-1800/2000)/0.05)+70;
4  dth=th-70;
5  disp(dth, 'change in temperature (degree C)')

```

Scilab code Exa 5.24 calculating the frequencies of oscillation

```
1 // calculating the frequencies of oscillation
2 clc;
3 C=500*10^-12;
4 R20=10000*(1-0.05*(20-25));
5 f20=1/(2*%pi*R20*C);
6 disp(f20,'Frequency of oscillation at 20 degree C (
    Hz)')
7 R25=10000*(1-0.05*(25-25));
8 f25=1/(2*%pi*R25*C);
9 disp(f25,'Frequency of oscillation at 25 degree C (
    Hz)')
10 R30=10000*(1-0.05*(30-25));
11 f30=1/(2*%pi*R30*C);
12 disp(f30,'Frequency of oscillation at 30 degree C (
    Hz)')
```

Scilab code Exa 5.25 Calculating the sensitivity and maximum output voltage

```
1 // Calculating the sensitivity and maximum output
    voltage
2 clc;
3 Se_thermocouple=500-(-72);
4 disp(Se_thermocouple,'Sensitivity of thermocouple (
    micro V/degree C)=')
5 Vo=Se_thermocouple*100*10^-6;
6 disp(Vo,'maximum output voltage(V)=')
```

Scilab code Exa 5.26 Calculating the temperature

```
1 // Calculating the temperature
2 clc;
3 ET=27.07+0.8;
4 Disp(ET, 'Required e.m.f.(mV) ')
5 disp('temperature corresponding to 27.87 mV is 620
      degree C')
```

Scilab code Exa 5.27 Calculating the series resistance and approximate error

```
1 // Calculating the series resistance and approximate
  error
2 clc;
3 Rm=50;
4 Re=12;
5 E=33.3*10^-3;
6 i=0.1*10^-3;
7 Rs=(E/i)-Rm-Re;
8 disp(Rs, 'series resistance (ohm)=')
9 Re=13;
10 i1=E/(Rs+Re+Rm);
11 AE=[(i1-i)/i]*800;
12 disp(AE, 'approximate error due to rise in resistance
      of 1 ohm in Re (degree C)=')
13 R_change=50*0.00426*10;
14 i1=E/(Rs+Re+Rm+R_change);
15 AE=[(i1-i)/i]*800;
16 disp(AE, 'approximate error due to rise in Temp. of
      10 (degree C)=')
```

Scilab code Exa 5.28 Calculate the values of resistance R1 and R2

```

1 // Calculate the values of resistance R1 and R2
2 clc;
3 E_20=0.112*10^-3; // emf at 20degree C
4 E_900=8.446*10^-3;
5 E_1200=11.946*10^-3;
6 E1=E_900-E_20;
7 E2=E_1200-E_20;
8 disp('E1=1.08*R1/(R1+2.5+R2);          (i)')
9 disp('E2=1.08*(R1+2.5)/(R1+2.5+R2);    (ii)')
10 disp('on solving (i) and (ii)')
11 R1=5.95;
12 R2=762.6;
13 disp(R1,'value of resistance R1 (ohm)=')
14 disp(R2,'value of resistance R2 (ohm)=')

```

Scilab code Exa 5.29 Calculate the percentage linearity

```

1 // Calculate the percentage linearity
2 clc;
3 linearity_percentage=(0.003/1.5)*100;
4 disp(linearity_percentage,'percentage linearity=')

```

Scilab code Exa 5.30 Calculate sensivity of the LVDT

```

1 // Calculate sensivity of the LVDT, Instrument and
  resolution of instrument in mm
2 clc;
3 displacement=0.5;
4 Vo=2*10^-3;
5 Se_LVDT=Vo/displacement;
6 disp(Se_LVDT,'sensivity of the LVDT (V/mm)')
7 Af=250;
8 Se_instrument=Se_LVDT*Af;

```



```

9 disp(Se_instrument, 'sensitivity of instrument (V/mm)')
   )
10 sd=5/100;
11 Vo_min=50/5;
12 Re_instrument=1*1/1000;
13 disp(Re_instrument, 'resolution of instrument in mm')

```

Scilab code Exa 5.31 calculate the deflection maximum and minimum force

```

1 // calculate the deflection , maximum and minimum
  force
2 clc;
3 b=0.02;
4 t=0.004;
5 I=(1/12)*b*t^3;
6 F=25;
7 l=0.25;
8 E=200*10^9;
9 x=(F*l^3)/(3*E*I);
10 disp(x, 'deflection (m)')
11 DpF=x/F;
12 Se=DpF*0.5*1000;
13 Re=(10/1000)*(2/10);
14 F_min=Re/Se;
15 F_max=10/Se;
16 disp(F_min, 'minimum force (N)')
17 disp(F_max, 'maximum force (N)')
18 disp(Se, '')

```

Scilab code Exa 5.32 calculating the sensitivity of the transducer

```

1 // calculating the sensitivity of the transducer
2 clc;

```

```

3 disp('permittivity of the air e0=8.85*10^-12')
4 e0=8.85*10^-12;
5 w=25*10^-3;
6 d=0.25*10^-3;
7 Se=-4*e0*w/d;
8 disp(Se,'sensitivity of the transducer (F/m)=')
```

Scilab code Exa 5.33 Calculate the value of the capacitance after the application of pressure

```

1 // Calculate the value of the capacitance after the
   application of pressure
2 clc;
3 C1=370*10^-12;
4 d1=3.5*10^-3;
5 d2=2.9*10^-3;
6 C2=C1*d1/d2;
7 disp(C2,'the value of the capacitance after the
   application of pressure (F)=')
```

Scilab code Exa 5.34 Calculate the change in frequency of the oscillator

```

1 // Calculate the change in frequency of the
   oscillator
2 clc;
3 fo1=100*10^3;
4 d1=4;
5 d2=3.7;
6 fo2=[(d2/d1)^0.5]*fo1;
7 dfo=fo1-fo2;
8 disp(dfo,'change in frequency of the oscillator (Hz)
   ')
```

Scilab code Exa 5.35 Calculate the dielectric stress change in value of capacitance

```
1 // Calculate the dielectric stress , change in value
  of capacitance
2 clc;
3 L_air=(3.1-3)/2;
4 D_stress=100/L_air;
5 e0=8.85*10^-12;
6 l=20*10^-3;
7 D2=3.1;
8 D1=3;
9 C=(2*%pi)*e0*l/(log(D2/D1));
10 disp(C, 'Capacitance (F)=')
11 l=(20*10^-3)-(2*10^-3);
12 C_new=(2*%pi)*e0*l/(log(D2/D1));
13 C_change=C-C_new;
14 disp(C_change, 'change in Capacitance (F)=')
```

Scilab code Exa 5.36 Calculate the value of time constant phase shift series resistance amplitude ratio and voltage sensitivity

```
1 // Calculate the value of time constant , phase shift ,
  series resistance , amplitude ratio and voltage
  sensitivity
2 clc;
3 M=0.95;
4 w=2*%pi*20;
5 tc=(1/w)*[(M^2)/(1-M^2)]^0.5;
6 disp(tc, 'time constant (s)')
7 ph={(%pi/2)-[atan(w*tc)]}*(180/%pi);
8 disp(ph, 'phase shift (deg)')
```

```

9 C=(8.85*10^-12*300*10^-6)/(0.125*10^-3);
10 R=tc/C;
11 disp(R,'series resistance (ohm)')
12 M=1/(1+(1/(2*pi*5*tc)^2))^0.5;
13 disp(M,'amplitude ratio=')
14 Eb=100;
15 x=0.125*10^-3;
16 Vs=Eb/x;
17 disp(Vs,'voltage sensitivity (V/m)')

```

Scilab code Exa 5.37 Calculate the change in capacitance and ratio

```

1 //Calculate the change in capacitance and ratio
2 clc;
3 e0=8.85*10^-12;
4 A=500*10^-6;
5 d=0.2*10^-3;
6 C=e0*A/d;
7 d1=0.18*10^-3;
8 C_new=e0*A/d1;
9 C_change=C_new-C;
10 Ratio=(C_change/C)/(0.02/0.2);
11 disp(Ratio,'ratio of per unit change of capacitance
    to per unit change of diaplacement')
12 d1=0.19*10^-3;
13 e1=1;
14 d2=0.01*10^-3;
15 e2=8;
16 C=(e0*A)/((d1/e1)+(d2/e2));
17 d1_new=0.17*10^-3;
18 C_new=(e0*A)/((d1_new/e1)+(d2/e2));
19 C_change=C_new-C;
20 Ratio=(C_change/C)/(0.02/0.2);
21 disp(Ratio,'ratio of per unit change of capacitance
    to per unit change of diaplacement')

```

Scilab code Exa 5.40 Calculate the output voltage and charge sensitivity

```
1 // Calculate the output voltage and charge
  sensitivity
2 clc;
3 g=0.055;
4 t=2*10^-3;
5 P=1.5*10^6;
6 Eo=g*t*P;
7 disp(Eo, 'output voltage (V)=')
8 e=40.6*10^-12;
9 d=e*g;
10 disp(d, 'charge sensitivity (C/N)=')
```

Scilab code Exa 5.41 Calculate the force

```
1 // Calculate the force
2 clc;
3 g=0.055;
4 t=1.5*10^-3;
5 Eo=100;
6 P= Eo/(g*t);
7 A=25*10^-6;
8 F=P*A;
9 disp(F, 'Force (N)=')
```

Scilab code Exa 5.42 Calculate the strain charge and capacitance clc

```
1 // Calculate the strain , charge and capacitance
```

```

2  clc;
3  A=25*10^-6;
4  F=5;
5  P=F/A;
6  d=150*10^-12;
7  e=12.5*10^-9;
8  g=d/(e);
9  t=1.25*10^-3;
10 Eo=(g*t*P);
11 strain=P/(12*10^6);
12 Q=d*F;
13 C=Q/Eo;
14 disp(strain, 'strain=')
15 disp(Q, 'charge (C)=')
16 disp(C, 'Capacitance (F)=')

```

Scilab code Exa 5.43 calculate peak to peak voltage swing under open and loaded conditions calculate maximum change in crystal thickness

```

1  // calculate peak to peak voltage swing under open
   // and loaded conditions
2  // calculate maximum change in crystal thickness
3  clc;
4  d=2*10^-12;
5  t=1*10^-3;
6  Fmax=0.01;
7  e0=8.85*10^-12;
8  er=5;
9  A=100*10^-6;
10 Eo_peak_to_peak=2*d*t*Fmax/(e0*er*A);
11 disp(Eo_peak_to_peak, 'peak voltage swing under open
   conditions ')
12 Rl=100*10^6;
13 Cl=20*10^-12;
14 d1=1*10^-3;

```

```

15 Cp=e0*er*A/d1;
16 C=Cp+C1;
17 w=1000;
18 m=[w*Cp*R1/[1+(w*C*R1)^2]^0.5];
19 El_peak_to_peak=[2*d*t*Fmax/(e0*er*A)]*m;
20
21 disp(El_peak_to_peak,'peak voltage swing under
    loaded conditions')
22 E=90*10^9;
23 dt=2*Fmax*t/(A*E);
24 disp(dt,'maximum change in crystal thickness (m)')

```

Scilab code Exa 5.44 Calculate the minimum frequency and phase shift

```

1 // Calculate the minimum frequency and phase shift
2 clc;
3 M=0.95;
4 tc=1.5*10^-3;
5 w=(1/tc)*[(M^2)/(1-M^2)]^0.5;
6 disp(w,'minimum frequency (rad/s)')
7 ph={(%pi/2)-[atan(w*tc)]}*(180/%pi);
8 disp(ph,'phase shift(deg)')

```

Scilab code Exa 5.45 calculate sensitivity of the transducer high frequency sensitivity Lowest frequency Calculate external shunt capacitance and high frequency sensitivity after connecting the external shunt capacitance

```

1 //calculate sensitivity of the transducer , high
    frequency sensitivity , Lowest frequency
2 // Calculate external shunt capacitance and high
    frequency sensitivity after connecting the
    external shunt capacitance
3 clc;

```

```

4 Kq=40*10^-3;
5 Cp=1000*10^-12;
6 K=Kq/Cp;
7 disp(K,'sensitivity of the transducer(V/m)')
8 Cc=300*10^-12;
9 Ca=50*10^-12;
10 C=Cp+Cc+Ca;
11 Hf=Kq/C;
12 disp(Hf,'high frequency sensitivity (V/m)')
13 R=1*10^6;
14 tc=R*C;
15 M=0.95;
16 w=(1/tc)*[(M^2)/(1-M^2)]^0.5;
17 f=w/(2*pi);
18 disp(w,'minimum frequency (s)')
19 disp('now f=10Hz')
20 f=10;
21 w=2*pi*f;
22 tc=(1/w)*[(M^2)/(1-M^2)]^0.5;
23 C_new=tc/R;
24 Ce=C_new-C;
25 disp(Ce,'external shunt capacitance(F)')
26 Hf_new=Kq/C_new;
27 disp(Hf_new,'new value of high frequency sensitivity
(V/m)')

```

Scilab code Exa 5.46 calculate op volatge

```

1 //
2 clc;
3 R=10^6;
4 C=2500*10^-12;
5 tc=R*C;
6 t=2*10^-3;
7 d=100*10^-12;

```



```

8 F=0.1;
9 e1=10^3*{d*F*[exp(-t/tc)]/C};
10 disp(e1,'voltage just before t=2ms (mV)')
11 e1_after=10^3*{d*F*[exp(-t/tc)-1]/C};
12 disp(e1_after,'voltage just after t=2ms (mV)')
13 disp('when t=10ms')
14 t=10*10^-3;
15 T=2*10
16 e_10=10^3*{d*F*[exp((-T/tc)-1)]*{exp(-(t-T))/tc}/C}
17 disp(e_10,'output voltage 10 ms after the
    application of impulse(mV) ')

```

Scilab code Exa 5.47 to prove time constant should be approximately 20T

```

1 // to prove time constant should be approximately 20
  T to keep undershoot within 5%
2 clc;
3 disp('Let T=1');
4 T=1;
5 e1=0.95;
6 tc=-T/log(e1);
7 disp(tc,'time constant')
8 disp('as T=1 so time constant should be
    approximately equal to 20T')

```

Scilab code Exa 5.48 calculate op volatge

```

1 //
2 clc;
3 Kh=-1*10^-6;
4 I=3;
5 B=0.5;
6 t=2*10^-3;

```

```
7 Eh=Kh*I*B/t;  
8 disp(Eh,'output voltage (V)')
```

Scilab code Exa 5.49 Calculate the threshold wavelength

```
1 // Calculate the threshold wavelength  
2 clc;  
3 Th_wavelength=1.24*10^-6/1.8'  
4 disp(Th_wavelength,'Threshold wavelength (m)')
```

Scilab code Exa 5.50 Calculate maximum velocity of emitted photo electrons

```
1 // Calculate maximum velocity of emitted photo  
  electrons  
2 clc;  
3 E_impacted=(1.24*10^-6)/(0.2537*10^-6);  
4 B_energy=E_impacted-4.30;  
5 em_ratio=0.176*10^12;  
6 v=(2*B_energy*em_ratio)^0.5;  
7 disp(v,'maximum velocity of emitted photo electrons  
  (m/s)')
```

Scilab code Exa 5.51 Calculate the resistance of the cell

```
1 // Calculate the resistance of the cell  
2 clc;  
3 Ri=30;  
4 Rf=100;  
5 t=10;
```

```

6 tc=72;
7 Rt=Ri+(Rf-Ri)*[1-exp(-t/tc)];
8 disp(Rt,'resistance of the cell (K ohm)')

```

Scilab code Exa 5.52 Calculate incident power and cut off frequency

```

1 //Calculate incident power and cut off frequency
2 clc;
3 I_power=250*0.2*10^-6;
4 disp(I_power,'incident power (W)')
5 Rl=10*10^3;
6 C=2*10^-12;
7 fc=1/(2*%pi*Rl*C);
8 disp(fc,'cut off frequency (Hz)')

```

Scilab code Exa 5.53 Calculate the internal resistance of cell and open circuit voltage

```

1 // Calculate the internal resistance of cell and
  open circuit voltage
2 clc;
3 I=2.2*10^-3;
4 Eo=0.33;
5 Rl=100;
6 Ri=(Eo/I)-100;
7 disp(Ri,'internal resistance of cell (ohm)')
8 Vo=0.33*[log(25)/log(10)];
9 disp(Vo,'open circuit voltage for a radiant
  incidence of 25 W/m2 (V)=')

```

Scilab code Exa 5.54 Find the value of current

```
1 // Find the value of current
2 clc;
3 A=1935*10^-6;
4 r=0.914;
5 S_angle=A/r^2;
6 I=180;
7 L_flux=I*S_angle;
8 disp(L_flux,'lumnious flux=')
9 disp('Corresponding to lumnious flux o.417 lm and a
      load resistance of 800 ohm the current is 120
      micro Ampere')
```

Chapter 6

Signal Conditioning

Scilab code Exa 6.1 calculating feedback resistance

```
1 // calculating feedback resistance
2 clc;
3 A=100;
4 R1=1*10^3;
5 Rf=-A*R1;
6 disp(Rf, 'feedback resistance (ohm)=');
```

Scilab code Exa 6.2 calculating the closed loop gain

```
1 // calculating the closed loop gain
2 clc;
3 Rf=10;
4 R1=1;
5 Avol=200000;
6 A=- (Rf/R1) * (1 / [1 + (1/Avol) * ((R1+Rf)/R1)]);
7 disp(A, 'closed loop gain=');
```

Scilab code Exa 6.3 calculating the maximum output voltage

```
1 // calculating the maximum output voltage
2 clc;
3 Sa=10;
4 disp(Sa, 'saturation voltage=')
5 Vom=Sa;
6 disp(Vom, 'maximum output voltage')
```

Scilab code Exa 6.4 calculating output voltage due to offset voltage

```
1 // calculating output voltage due to offset voltage
2 clc;
3 Vos=5*10^-3;
4 Rf=10;
5 R1=1;
6 Vo=-Vos*(1+Rf/R1);
7 disp(Vo, 'output voltage due to offset voltage (V)=')
```

Scilab code Exa 6.5 calculating Amplification factor

```
1 // calculating Amplification factor
2 clc;
3
4 Rf=10;
5 R1=1;
6 A=Rf/R1;
7 disp(A, 'Amplification Factor=')
```

Scilab code Exa 6.6 calculating output voltage due to offset voltage

```

1 // calculating output voltage due to offset voltage
2 clc;
3 V1=1;
4 V2=-2;
5 Rf=500;
6 R1=250;
7 R2=100;
8 Vo=-{[(Rf/R1)*V1]+[(Rf/R2)*V2]};
9 disp(Vo,'output voltage (V)=')

```

Scilab code Exa 6.7 calculating gain and feedback resistance

```

1 // calculating gain and feedback resistance
2 clc;
3
4 Rf=100*10^3;
5 R1=1*10^3;
6 A=Rf/R1;
7 disp(A,'Gain=')
8 disp('If multiplier is 10')
9 A=10;
10 Rf=A*R1;
11 disp(Rf,'feedback resistance (Ohm)=')

```

Scilab code Exa 6.8 Calculating the values of resistances

```

1 // Calculating the values of resistances
2 clc;
3 g=10;
4 Rf=10;
5 R1=Rf/g;
6 disp(R1,'resistance R1(Kilo-ohms)=')
7 R2=Rf/(0.5*g);

```

```
8 disp(R2, 'resistance R1(Kilo-ohms)=')
9 R3=Rf/(0.333*g);
10 disp(R3, 'resistance R1(Kilo-ohms)=')
```

Scilab code Exa 6.9 Calculating the value of resistance and capacitance

```
1 // Calculating the value of resistance and
   capacitance
2 clc;
3 Voramp=-10;
4 disp('if voltage source is 10V then RC= 1 ms and if
   C=1 micro-F')
5 C=1;
6 R=1*10^-3*10^6;
7 disp(R, 'value of resistance (ohm)=')
```

Scilab code Exa 6.10 Calculating Difference mode gain and output voltage

```
1 // Calculating Difference mode gain and output
   voltage
2 clc;
3 V2=5*10^-3;
4 V1=3*10^-3;
5 Vo=300*10^-3;
6 Vd=V2-V1;
7 Ad=Vo/Vd;
8 disp(Ad, 'difference mode gain=')
9 V2=155*10^-3;
10 V1=153*10^-3;
11 Vo=Ad*(V2-V1);
12 disp(Vo, 'output voltage (V)=')
```

Scilab code Exa 6.11 Calculating Difference mode Common mode gain and CMRR

```
1 // Calculating Difference mode, Common mode gain and
  CMRR
2 clc;
3 Vo=3;
4 Vd=30*10^-3;
5 Ad=Vo/Vd;
6 disp(Ad, 'difference mode gain=')
7 Vo=5*10^-3;
8 Vc=500*10^-3;
9 Ac=Vo/Vc;
10 disp(Ac, 'Common mode gain=')
11 CMRR=Ad/Ac;
12 disp(CMRR, 'Common mode rejection ratio=')
```

Scilab code Exa 6.12 Calculating Signal to noise ratio and CMRR

```
1 // Calculating Signal to noise ratio and CMRR
2 clc;
3 V2=30*10^-3;
4 V1=-30*10^-3;
5 Vd=V2-V1;
6 Ad=150;
7 Vos=Ad*Vd;
8 Ac=0.04;
9 Vc=600*10^-3;
10 Von=Ac*Vc;
11 SNR=Vos/Von;
12 CMRR=Ad/Ac;
13 disp(SNR, 'Signal to Noise Ratio=')
```

```
14
15 disp(CMRR, 'CMRR=')
```

Scilab code Exa 6.13 Calculating sensitivity and output voltage

```
1 // Calculating sensitivity and output voltage
2 clc;
3 Ci=10*10^-12;
4 Vi=10;
5 Eo=8.85*10^-12;
6 A=200*10^-6;
7 K=-Ci*Vi/(Eo*A);
8 disp(K, 'sensitivity (V/mm)=')
9 d=1*10^-6;
10 Vo=K*d;
11 disp(Vo, 'output voltage (V)=')
```

Scilab code Exa 6.14 calculating minimum maximum time constants and value of frequencies

```
1 // calculating minimum, maximum time constants and
   value of frequencies
2 clc;
3 MXtc= 10^10*1000*10^-12;
4 disp(MXtc, 'Maximum time constant (s)');
5 MNtc= 10^8*10*10^-12;
6 disp(MNtc, 'Minimum time constant (s)');
7 AR=0.95;
8 fmin=(AR)/[2*%pi*MXtc*(1-AR^2)^0.5];
9 disp(fmin, 'minimum frequency (Hz)')
10 fmax=(AR)/[2*%pi*MNtc*(1-AR^2)^0.5];
11 disp(fmax, 'Maximum frequency (Hz)')
```

Scilab code Exa 6.15 calculating time constant and value of capacitance

```
1 // calculating time constant and value of
   capacitance
2 clc;
3 g=0.501;
4 f=50;
5 w=2*%pi*f;
6 tc=(1-g^2)^0.5/(w*g);
7 disp(tc, 'time constant (s)')
8 R=10000;
9 C=(tc/R)*10^6;
10 disp(C, 'capacitance (micro-F)')
```

Scilab code Exa 6.16 calculating the passband gain and upper and lower cut off frequencies

```
1 // calculating the passband gain and upper & lower
   cut off frequencies
2 clc;
3 R1=10*10^3;
4 R2=1*10^6;
5 A=R2/(R1+R2);
6 disp(A, 'gain=')
7 C2=(0.01)*10^-6;
8 C1=100*10^-12;
9 fcl=1/(2*%pi*C2*R2);
10 disp(fcl, 'lower cut off frequency (Hz)')
11 fcu=1/(2*%pi*R1*C1);
12 disp(fcu, 'upper cut off frequency (Hz)')
```

Scilab code Exa 6.17 calculating the value of C

```
1 // calculating the value of C
2 clc;
3 R=1*10^6;
4 fo=10*10^3;
5 C=1/(2*%pi*fo*R);
6 disp(C, 'the value of C (F)')
```

Scilab code Exa 6.19 calculate the output voltage and sensitivity

```
1 // calculate the output voltage and sensitivity
2 clc;
3 Rt=100;
4 K=1;
5 Rb=K*Rt;
6 ei=10;
7 disp('When K=1')
8 eo=[(K*Rt/Rb)/(1+(K*Rt/Rb))]*ei;
9 disp(eo, 'output voltage (V)= ')
10 Se=(ei*Rb)/[(Rb+K*Rt)^2];
11 disp(Se, 'sensitivity (V/ohm)= ')
12 K=0.95;
13 disp('When K=0.95')
14 eo=[(K*Rt/Rb)/(1+(K*Rt/Rb))]*ei;
15 disp(eo, 'output voltage (V)= ')
16 Se=(ei*Rb)/[(Rb+K*Rt)^2];
17 disp(Se, 'sensitivity (V/ohm)= ')
```

Scilab code Exa 6.20 calculate the output voltage for different values of K

```
1 // calculate the output voltage for different values
  of K
2 clc;
3 ei=100;
4 K=0.25;
5 disp('When K=0.25 ')
6 eo=[(K/6)/(1+(K/6))]*ei;
7 disp(eo,'output voltage (V)= ')
8 K=0.5;
9 disp('When K=0.5 ')
10 eo=[(K/6)/(1+(K/6))]*ei;
11 disp(eo,'output voltage (V)= ')
12 K=0.6;
13 disp('When K=0.6 ')
14 eo=[(K/6)/(1+(K/6))]*ei;
15 disp(eo,'output voltage (V)= ')
16 K=0.8;
17 disp('When K=0.8 ')
18 eo=[(K/6)/(1+(K/6))]*ei;
19 disp(eo,'output voltage (V)= ')
```

Scilab code Exa 6.21 calculating the resistance and output voltage

```
1 // calculating the resistance and output voltage
2 clc;
3 R2=119;
4 R3=119.7;
5 R1=120.4;
6 R4=R2*R3/R1;
7 R4=121.2;
8 ei=12;
9 eo=[(R1*R4-R2*R3)/((R1+R3)*(R2+R4))]*ei;
```

```
10 disp(eo, 'output voltage (V)=')
```

Scilab code Exa 6.22 Calculating the bridge output

```
1 // Calculating the bridge output
2 clc;
3 ei=6;
4 R=10000;
5 disp('if dR=0.05R')
6 dR=0.05*R;
7 eo=[(dR/R)/(4+2*(dR/R))]*ei;
8 disp(eo, 'output voltage (V)')
9 disp('if dR=-0.05R')
10 dR=-0.05*R;
11 eo=[(dR/R)/(4+2*(dR/R))]*ei;
12 disp(eo, 'output voltage (V)')
```

Scilab code Exa 6.23 Calculating the resistance of unknown resistance

```
1 // Calculating the resistance of unknown resistance
2 clc;
3 R2=800;
4 R3=800;
5 R4=800;
6 Rm=100;
7 R=800;
8 ei=4;
9 im=0.8*10^-6;
10 dR=(im*R^2)*(4*(1+Rm/R))/ei;
11 R1=R+dR;
12 disp(R1, 'Resistance of unknown resistor (ohm)=')
```

Scilab code Exa 6.24 calculating the current

```
1 // calculating the current
2 clc;
3 R2=1000;
4 R3=1000;
5 R1=1010;
6 R4=1000;
7 ei=100;
8 eo=[(R1*R4-R2*R3)/((R1+R3)*(R2+R4))]*ei;
9 disp(eo, 'open circuit voltage (V)=')
10 Ro=[R1*R4/(R1+R4)]+[R2*R3/(R2+R3)];
11 Rm=4000;
12 im=eo/(Ro+Rm);
13 disp(im, 'current (A)=')
```

Scilab code Exa 6.25 Calculating maximum permissible current through strain gauge supply voltage and Power dissipation in series resistance

```
1 // Calculating maximum permissible current through
   // strain gauge, supply voltage
2 // and Power dissipation in series resistance
3 clc;
4 R=100;
5 P=250*10^-3;
6 i=(P/R)^0.5;
7 disp(i, 'maximum permissible current (A)=')
8 ei=2*i*R;
9 disp(ei, 'maximum supply voltage (V)=')
10 Rs=100;
11 Ps=10^2/Rs;
```

```
12 disp(Ps, 'Power dissipation in series resistance (W) '
    )
```

Scilab code Exa 6.26 Calculating the maximum voltage sensitivity of the bridge

```
1 // Calculating the maximum voltage sensitivity of
    the bridge
2 clc;
3 P=(0.1/0.2)*10^-3;
4 R=1000;
5 eim=2*(P*R)^0.5;
6 dth=0.1;
7 dR=(4.5/100)*dth*R;
8 eom=(dR/(4*R))*eim;
9 Sem=eom/dth;
10 disp(Sem, 'maximum voltage sensitivity of the bridge
    (V)=')
```

Scilab code Exa 6.27 Calculating the resolution of the instrument quantization error and decision levels

```
1 // Calculating the resolution of the instrument,
    quantization error and decision levels
2 clc;
3 Reso=10*10^-3/10;
4 disp (Reso, 'resolution of the instrument=')
5 n=10;
6 Q=10/2^n;
7 Eq=Q/(2*3^0.5);
8 disp (Eq, 'quantization error=')
9 D=(2^n)-1;
10 disp (D, 'decision levels=')
```

Scilab code Exa 6.28 Calculating the weight of MSB and LSB

```
1 // Calculating the weight of MSB and LSB
2 clc;
3 Ra=10;
4 b=5;
5 Wmsb=Ra/2;
6 disp(Wmsb, 'weight of MSB (V)=')
7 Wlsb=Ra/2^b;
8 disp(Wlsb, 'weight of LSB (V)=')
```

Scilab code Exa 6.29 Calculating reference voltage and percentage change

```
1 // Calculating reference voltage and percentage
   change
2 clc;
3 E=10;
4 ER=E*256/255;
5 disp(ER, 'Reference voltage (V)=')
6 n=8;
7 CVlsb=(2^-n)*ER;
8 PC=CVlsb*100/E;
9 disp(PC, 'Percentage change =')
```

Scilab code Exa 6.30 Calculating the number of bits Value of LSB Quantization error minimum sampling rate Aperture time and dynamic range

```

1 // Calculating the number of bits , Value of LSB,
   Quantization error ,minimum sampling rate
   Aperature time and dynamic range
2 clc;
3 n=14;
4 disp(n, 'number of bits =')
5 E=10;
6 Q=10;
7 LSB=E/2n;
8 disp(LSB, 'Value of LSB (V) =')
9 Eq=Q/(2*(30.5));
10 disp(Eq, 'Quantization error (V) =')
11 fh=1000;
12 fs=5*fh;
13 disp(fs, 'minimum sampling rate (Hz) =')
14 a=1/16384;
15 ta=1/(2*%pi*fh)*a;
16 disp(ta, 'Aperature time (s) =')
17 Dr=6*n;
18 disp(Dr, 'dynamic range (db) =')

```

Scilab code Exa 6.31 Calculating the value of resistance and smallest output current

```

1 // Calculating the value of resistance and smallest
   output current
2 clc;
3 ER=10;
4 n=6;
5 Imax=10*10-3;
6 R=ER*((2n-1)/[(2(n-2))*Imax];
7 disp(R, 'resistance (ohm)=')
8 LSB=ER/[(2(n-1))*R];
9 disp(LSB, 'smallest output current (A)')

```

Scilab code Exa 6.32 Calculating the output voltage

```
1 // Calculating the output voltage
2 clc;
3 n=6;
4 R=10000;
5 Io= (10/10*10^3)
      *{1*1+1*0.5+1*0.25+0*0.125+1*0.0625}*10^-6;
6 Rf=5000;
7 Eo=-Io*Rf;
8 disp(Eo, 'Output voltage (V)=')
```

Scilab code Exa 6.33 Calculate the output of successive approximation A to D

```
1 // Calculate the output of successive approximation
  A/D
2 clc;
3 disp('Set d3=1')
4 Output=5/2^1;
5 disp('since 3.217>2.5 so d3=1')
6 disp('Set d2=1')
7 Output=(5/2^1)+(5/2^2);
8 disp('since 3.217< 3.75 so d2=0')
9 disp('Set d1=1')
10 Output=(5/2^1)+(5/2^3);
11 disp('since 3.217>3.125 so d1=1')
12 disp('Set d0=1')
13 Output=(5/2^1)+(5/2^3)+(5/2^4);
14 disp('since 3.217<3.4375 so d0=0')
15 disp('Output of successive approximation A/D = 1010 '
      )
```

Scilab code Exa 6.34 to calculate op dc voltage

```
1 //to calculate o/p dc voltage
2
3 clc;
4 t=400;
5 T=t/4;
6 C=1*10^-6;
7 v=20;
8 i=C*100*v/(T);
9 R=1*10^3;
10 e_o=i*R;
11 disp(e_o, 'output voltage(V)');
```

Chapter 7

Display Devices and recorders

Scilab code Exa 7.1 calculating resolution

```
1 // calculating resolution
2 clc;
3 N = 4;
4 R=1/10^N;
5 disp(R, 'Resolution of the meter=');
6 VR=1;
7 R1=VR*R;
8 disp(R1, 'Resolution of the meter for voltage range 1
   V=');
9 VR1=10;
10 R2=VR1*R;
11 disp(R2, 'Resolution of the meter for voltage range
   10V=');
```

Scilab code Exa 7.2 calculating resolution

```
1 // calculating resolution
2 clc;
```

```

3 N = 3;
4 R=1/10^N;
5 disp(R, 'Resolution of the meter=');
6 disp('12.98 will be displayed as 12.980 on 10V scale
      ')
7 VR=1;
8 R1=VR*R;
9 disp(R1, 'Resolution of the meter for voltage range 1
      V=');
10 disp('0.6973 will be displayed as 0.6973 on 1V scale
      ')
11 VR1=10;
12 R2=VR1*R;
13 disp(R2, 'Resolution of the meter for voltage range
      10V=');
14 disp('0.6973 will be displayed as 00.697 on 10V
      scale ')

```

Scilab code Exa 7.3 calculating Total possible error and percentage error

```

1 // calculating Total possible error and percentage
  error
2 clc;
3 R=5;
4 V=0.005*R;
5 disp(V, '0.5 percent of the reading')
6 TPE=V+0.01;
7 disp(TPE, 'Total possible error (V)=')
8 R1=0.10;
9 V1=0.005*R1;
10 TPE1=V1+0.01;
11 disp(TPE1, 'Total possible error (V)=')
12 PE=(TPE1/0.1)*100;
13 disp(PE, 'Percentage error=')

```

Scilab code Exa 7.4 calculating frequency

```
1 // calculating frequency
2 clc;
3 N=034;
4 t=10*10^-3;
5 f=N/t;
6 disp(f, 'frequency (Hz)=')
```

Scilab code Exa 7.5 calculating maximum error

```
1 // calculating maximum error
2 clc;
3 R=5*10^6;
4 V=0.00005*R;
5 disp(V, '0.005 percent of the reading (micro sec)=');
6 LSD=1;
7 ME=V+1;
8 disp(ME, 'Maximum error (micro sec)=')
9 R=500;
10 V=0.00005*R;
11 disp(V, '0.005 percent of the reading (sec)=');
12 LSD=1;
13 ME=V+1;
14 disp(ME, 'Maximum error (sec)=')
```

Scilab code Exa 7.6 calculating number of turns and current

```
1 // calculating number of turns and current
```

```

2  clc;
3  D=8*10-3;
4  A=D2;
5  disp(A, 'A=')
6  J=8*10-3;
7  K=16*10-3;
8  B=4*J*K;
9  disp (B, 'B=')
10 disp('since A<B so the instrument is underdamped')
11 th=(100*%pi)/180;
12 i=10*10-3;
13 F=0.2*10-6;
14 G=(K*th+F)/i;
15 l=65*10-3;
16 d=25*10-3;
17 N=G/(B*l*d);
18 disp(N, 'number of turns=')
19 i=F/G;
20 disp(i, 'current required to overcome friction (A)')

```

Scilab code Exa 7.7 calculating speed of the tape

```

1  // calculating speed of the tape
2  clc;
3  Lam=2.5*6.25;
4  f=50000;
5  S=Lam*10-6*f;
6  disp(S, 'speed (m/s)=')

```

Scilab code Exa 7.8 calculating number density of the tape

```

1  // calculating number density of the tape
2  clc;

```



```
3 ND=12000/1.5;
4 disp(ND, 'Number density (numbers/mm)')
```

Scilab code Exa 7.9 Calculating possible phase angles

```
1 // Calculating possible phase angles
2 clc;
3 Y1=1.25;
4 Y2=2.5;
5 PA=asind(Y1/Y2);
6 disp(PA, 'phase angle (degree)')
7 disp('possible angle are 30 degree and 330 degree')
```

Scilab code Exa 7.10 Calculating possible phase angles

```
1 // Calculating possible phase angles
2 clc;
3 disp('if spot generating pattern moves in the
      clockwise direction')
4 Y1=0;
5 Y2=5;
6 PA=asind(Y1/Y2);
7 disp(PA, 'phase angle (degree)')
8 Y1=2.5;
9 Y2=5;
10 PA=asind(Y1/Y2);
11 disp(PA, 'phase angle (degree)')
12 Y1=3.5;
13 Y2=5;
14 PA=asind(Y1/Y2);
15 disp(PA, 'phase angle (degree)')
16 Y1=2.5;
17 Y2=5;
```

```
18 PA=180-[asind(Y1/Y2)];  
19 disp(PA,'phase angle (degree)')
```

Chapter 8

Metrology

Scilab code Exa 8.1 calculate the arrangement of slip gauges

```
1 // calculate the arrangement of slip gauges
2 clc;
3 Dd=52.215;
4 disp(Dd, 'desired value=')
5 Pb=4;
6 disp(Pb, 'Protected block=')
7 R=Dd-Pb;
8 disp(R, 'Reminder=')
9 Tp=1.005;
10 disp(Tp, 'thousand block=')
11 R=R-Tp;
12 disp(R, 'Reminder=')
13 Hp=1.010;
14 disp(Hp, 'Hunderths block=')
15 R=R-Hp;
16 disp(R, 'Reminder=')
17 Ttp=2.20;
18 disp(Ttp, 'tenths block=')
19 R=R-Ttp;
20 disp(R, 'Reminder=')
21 Up=4;
```

```

22 disp(Up, 'unit block=')
23 R=R-Up;
24 disp(R, 'Reminder=')
25 Tp=40;
26 disp(Tp, 'Tens block=')
27 R=R-Tp;
28 disp(R, 'Reminder=')

```

Scilab code Exa 8.2 calculate the sensitivity

```

1 // calculate the sensitivity
2 clc;
3 Ps=200*10^3;
4 r=0.6;
5 d2=0.5;
6 d1=0.5;
7 a=(d2/d1^2);
8 x1=(1.1-r)/(2*a);
9 disp(x1, 'x1=')
10 r=0.8;
11 d2=0.5;
12 d1=0.5;
13 a=(d2/d1^2);
14 x2=(1.1-r)/(2*a);
15 disp(x2, 'x2=')
16 x=x1-x2;
17 disp(x, 'so the range is x (mm)')
18 hS=%pi*d2*10^-3;
19 A2=%pi*d2*10^-6*(x1+x2)/2;
20 pS=-0.4*Ps/A2;
21 pgS=25*10^-3/1000;
22 S=hS*pS*pgS;
23 disp(S, 'sensitivity=')

```

Scilab code Exa 8.3 calculate uncertainty in displacement

```
1 // calculate uncertainty in displacement
2 Pi=70*10^3;
3 r=0.4;
4 d2=1.6;
5 d1=0.75;
6 a=(d2/d1^2);
7 x1=(1.1-r)/(2*a);
8 disp(x1, 'x1=')
9 r=0.9;
10 x2=(1.1-r)/(2*a);
11 disp(x2, 'x2=')
12 x=x1-x2;
13 disp(x, 'so the range is x (mm)')
14 d=-2*a;
15 Wr=12.5/Pi;
16 Wx=Wx/d;
17 disp(Wx, 'uncertainty in displacement (mm)')
```

Scilab code Exa 8.4 calculate difference between height of workpieces and pile of slip gauges

```
1 // calculate difference between height of workpieces
  and pile of slip gauges
2 clc;
3 N=12;
4 lem=0.644;
5 d=N*lem/2;
6 disp(d, 'difference between height of workpieces and
  pile of slip gauges (micro-meter)')
```

Scilab code Exa 8.5 calculate separation distance between two surfaces and angle of tilt

```
1 // calculate separation distance between two
   surfaces and angle of tilt
2 clc;
3 N=5;
4 lem=546*10-9;
5 d=[(2*N-1)*lem*106]/4;
6 disp(d,'separation distance between two surfaces(
   micro-meter)')
7 x=75;
8 th=atan(d/x);
9 disp(th,'angle of tilt')
```

Scilab code Exa 8.6 Calculate the difference in two diameters

```
1 // Calculate the difference in two diameters
2 clc;
3 x=20/12;
4 L=50-10;
5 lem=0.6;
6 d=(L*lem)/(2*x);
7 disp(d,'difference in diameters of the rollers(micro
   -meter)')
```

Scilab code Exa 8.7 Calculate the change in thickness along its length

```
1 // Calculate the change in thickness along its
   length
2 clc;
3 d=4.5-2.5;
4 Tg=2*(0.5)*0.509;
5 disp(Tg,'change in thickness along its length(micro-
   meter)')
```

Chapter 9

Pressure Measurements

Scilab code Exa 9.1 calculating the length of mean free path

```
1 // calculating the length of mean free path
2 clc;
3 T=273+20;
4 P=101.3*103;
5 mfp=22.7*10-6*T/P;
6 disp(mfp,'length of mean free path when pressure is
   one atmospheric pressure(m)')
7 P=133;
8 mfp=22.7*10-6*T/P;
9 disp(mfp,'length of mean free path when pressure is
   one torr(m)')
10 P=133*10-3;
11 mfp=22.7*10-6*T/P;
12 disp(mfp,'length of mean free path when pressure is
   one micrometer of Hg(m)')
13 P=249.1;
14 mfp=22.7*10-6*T/P;
15 disp(mfp,'length of mean free path when pressure is
   one inch of water(m)')
16 P=133*10-6;
17 mfp=22.7*10-6*T/P;
```



```
18 disp(mfp, 'length of mean free path when pressure is  
10-3 micrometer of Hg(m)')
```

Scilab code Exa 9.2 Calculate Pressure of air source

```
1 // Calculate Pressure of air source  
2 clc;  
3 T=273+25;  
4 P=99.22*103;  
5 R=288;  
6 df=P/(R*T);  
7 dm=0.82*996;  
8 g=9.81;  
9 h=200*10-6;  
10 P1=g*h*(dm-df)*103;  
11 Pa=P+P1;  
12 disp(Pa, 'Pressure of air source (N/m2)')
```

Scilab code Exa 9.3 Calculate Pressure head

```
1 // Calculate Pressure head  
2 clc;  
3 df=1*103;  
4 dm=13.56*103;  
5 g=9.81;  
6 h=130*10-3;  
7 P=g*h*(dm-df);  
8 Ph=P/9.81;  
9 disp(Ph, 'Pressure head (mm of water)')
```

Scilab code Exa 9.4 calculate height

```
1 // calculate hight
2 clc;
3 hn =250;
4 d=5;
5 D=25;
6 h=hn*(1+(d/D)^2);
7 disp(h, 'height')
```

Scilab code Exa 9.6 calculate error interms of pressure

```
1 // calculate error interms of pressure
2 clc;
3 P=8*133;
4 h=P/(800*9.81);
5 d=2;
6 D=50;
7 hn=h/(1+(d/D)^2);
8 e=(hn-h)/h*100;
9 eP=0.8*1000*9.81*(hn-h);
10 disp(eP, 'error interms of pressure (N/m2)')
```

Scilab code Exa 9.7 calculate angle to which tube is incliend to vertical

```
1 // calculate angle to which tube is incliend to
  vertical
2 clc;
3 P=133;
4 g=9.81;
5 dm=13.56*10^3;
6 R=10^-3;
7 d=4;
```

```

8 D=20;
9 th=asind(P/(g*dm*R*(1+(d/D)^2)));
10 thV=90-th;
11 disp(thV,'angle to which tube is incliend to
    vertical(degree)')

```

Scilab code Exa 9.8 calculate angle to which tube is incliend to horizontal

```

1 // calculate angle to which tube is incliend to
    horizontal
2 clc;
3 P=9.81;
4 g=9.81;
5 dm=0.864*10^3;
6 R=4*10^-3;
7 d=2;
8 D=20;
9 th=asind(P/(g*dm*R*(1+(d/D)^2)));
10 disp(th,'angle to which tube is incliend to
    horizontal(degree)')

```

Scilab code Exa 9.9 calculate Length of scale angle to which tube is incliend to horizontal

```

1 // calculate Length of scale angle to which tube is
    incliend to horizontal
2 clc;
3 P=500*9.81;
4 g=9.81;
5 d=8;
6 a= (%pi/4)*d^2;
7 A=1200;
8 dm=0.8*10^3;

```

```

9 hn=P/(g*dm*(1+(a/A)));
10 disp(hn,'Length of scale (m)')
11 R=0.6;
12 P1=50*9.81;
13 th=asind(P1/(g*dm*R*[1+(a/A)]));
14 disp(th,'angle to which tube is incliend to
    horizontal (degree)')

```

Scilab code Exa 9.10 calculate diameter of the tube

```

1 // calculate diameter of the tube
2 clc;
3 P=100*10^3;
4 g=9.81;
5 di=10*10^-3;
6 D=40*10^-3;
7 A= (%pi/4)*D^2;
8 dm=13.6*10^3;
9 a=A/[P/(dm*g*di)-1];
10 d=(4*a/%pi)^0.5*10^3;
11 disp(d,'diameter of the tube (mm)')

```

Scilab code Exa 9.11 calculate amplification ratio and percentage error

```

1 // calculate amplification ratio and percentage
  error
2 clc;
3 AR=1/(0.83-0.8);
4 disp(AR,'Amplification ratio')
5 D=50*10^-3;
6 A= (%pi/4)*D^2;
7 d=6*10^-3;
8 a= (%pi/4)*d^2;

```

```
9 PR=(a/A)*100;
10 disp(PR, 'percentage error')
```

Scilab code Exa 9.12 calculate value of counter weight required

```
1 // calculate value of counter weight required
2 clc;
3 P=981;
4 g=9.81;
5 d=500*10^-3;
6 A= (%pi/4)*(10*10^-3)^2;
7 R=275*10^-3;
8 th=30;
9 W=A*d*P/(2*g*R*sind(th));
10 disp(W, 'value of counter weight required(kg)')
```

Scilab code Exa 9.13 calculate damping factor time constant error and time lag calculate damping factor natural frequency time constant error and time lag

```
1 // calculate damping factor , time constant , error
  and time lag
2 // calculate damping factor , natural frequency , time
  constant , error and time lag
3 clc;
4 Mp1=20/40;
5 Mp2=10/40;
6 Mp3=5/40;
7 Eta=0.225;
8 disp(Eta, 'damping factor')
9 Td=1.2;
10 wd=2*%pi/Td;
11 wn=wd/[(1-Eta^2)^0.5];
```

```

12 tc=1/wn;
13 disp(tc,'time constant(s)')
14 ess=2*Eta/wn;
15 ess5=5*ess;
16 disp(ess5,'error for 5mm/s ramp(mm)')
17 Tlag=2*Eta*tc;
18 disp(Tlag,'time lag(s)')
19 Eta1=Eta*(0.5)^0.5;
20 disp(Eta1,'New damping factor')
21 Td=1.2;
22 wn1 = wn*(0.5)^0.5;
23 disp(wn1,'New natural frequency(rad/s)')
24 tc1=1/wn;
25 disp(tc1,'New time constant(s)')
26 ess51=ess5;
27 disp(ess51,'new error for 5mm/s ramp(mm)')
28 Tlag1=Tlag;
29 disp(Tlag1,'new time lag(s)');

```

Scilab code Exa 9.14 calculate thickness of diaphragm and natural frequency

```

1 // calculate thickness of diaphragm and natural
  frequency
2 clc;
3 P=7*10^6;
4 R=6.25*10^-3;
5 v=0.28;
6 E=200*10^9;
7 t={ [9*P*R^4*(1-v^2)/(16*E)]^0.25}*10^3;
8 disp(t,'thickness of diaphragm(mm)')
9 ds=7800;
10 fn=[2.5*t/(%pi*R^2)]*[E/(3*ds*(1-v^2))]^0.5;
11 disp(fn,'natural frequency(Hz)')

```

Scilab code Exa 9.15 calculate the natural length of the spring and displacement

```
1 // calculate the natural length of the spring and
   displacement
2 clc;
3 P=100*10^3;
4 A=1500*10^-6;
5 F=P*A;
6 Cs=F/3;
7 Ls=Cs+40;
8 disp(Ls, 'natural length of spring (mm)')
9 P1=10*10^3;
10 F1=P1*A;
11 Ss=3+2*.5;
12 D=F1/Ss;
13 disp(D, 'displacement (mm)')
```

Scilab code Exa 9.16 calculate the open circuit voltage

```
1 // calculate the open circuit voltage
2 clc;
3 P=200*10^3;
4 R=70*10^-3;
5 v=0.25;
6 t=1*10^-3;
7 r=60*10^-3;
8 E=200*10^9;
9 Sr=[3*P*R^2*v/(8*t^2)]*{(1/v+1)-(3/v+1)*(r/R)^2};
10 St=[3*P*R^2*v/(8*t^2)]*{(1/v+1)-(1/v+3)*(r/R)^2};
11 Sta2=(Sr-v*St)/E;
12 Sta3=(Sr-v*St)/E;
```

```

13 r0=10*10^-3;
14 Sr1=[3*P*R^2*v/(8*t^2)]*{(1/v+1)-(3/v+1)*(r0/R)^2};
15 St1=[3*P*R^2*v/(8*t^2)]*{(1/v+1)-(1/v+3)*(r0/R)^2};
16 Sta1=(Sr1-v*St1)/E;
17 Sta4=(Sr1-v*St1)/E;
18 Gf=1.8;
19 ei=12;
20 eo=(Sta1+Sta4-Sta2-Sta3)*Gf*ei/4;
21 disp(eo,'output voltage (V)')

```

Scilab code Exa 9.17 calculate the optimum setting

```

1 // calculate the optimum setting
2 clc;
3 Aou=700*25*1/100;
4 Aol=100*25*1/100;
5 AouPtP= 2*Aou;
6 AolPtP= 2*Aol;
7 Se1=1;
8 D1=AouPtP/Se1;
9 disp(D1,'deflection of screen corresponding to
    maximum pressure for sensitivity of 1mV/mm (mm)')
10 disp('sinch the length of the screen is 100mm so
    waveform is out of range and hence sensitivity
    setting of 1mV/mm should not be used')
11 Se2=5;
12 D2=AouPtP/Se2;
13 disp(D2,'deflection of screen corresponding to
    maximum pressure for sensitivity of 5mV/mm (mm)')
14 disp('delection is within the range')
15 Se3=20;
16 D3=AouPtP/Se3;
17 disp(D3,'deflection of screen corresponding to
    maximum pressure for sensitivity of 20mV/mm (mm)')

```



```

18 disp('delection is within the range')
19 Se4=100;
20 D4=AouPtP/Se4;
21 disp(D4,'deflection of screen corresponding to
    maximum pressure for sensitivity of 100mV/mm (mm)
    ')
22 disp('delection is within the range')
23 Se5=500;
24 D5=AouPtP/Se5;
25 disp(D5,'deflection of screen corresponding to
    maximum pressure for sensitivity of 500mV/mm (mm)
    ')
26 disp('delection is within the range')
27 disp('since the sensitivity of 5mV/mm gives higher
    deflection so it is the optimum sensitivity')

```

Scilab code Exa 9.18 calculate the output voltage of bridge

```

1 // calculate the output voltage of bridge
2 clc;
3 dP=(7000*10^3)-(100*10^3);
4 b=25*10^-12;
5 R1=100;
6 dR=R1*b*dP;
7 ei=5;
8 deo=dR*ei/(4*R1)
9 disp(deo,'output voltage of bridge(V)')

```

Scilab code Exa 9.19 calculate attenuation

```

1 // calculate attenuation
2 clc;
3 T=273+20;

```

```

4 P=101.3*10^3;
5 R=287;
6 de=P/(R*T);
7 C=20.04*T^0.5;
8 r=6.25*10^-3;
9 L=0.6;
10 V=%pi*[(12.5*10^-3)^2]*(12.5*10^-3);
11 wn=C*r*(%pi/(V*(L+0.5*%pi*r)))^0.5;
12 fn=wn/(2*%pi);
13 f=1000;
14 u=f/fn;
15 mu=19.1*10^-6;
16 eta=[2*mu/(de*C*r^3)]*[3*L*V/%pi]^0.5;
17 M=1/{[(1-u^2)^2]+[(2*eta*u)^2]}^0.5;
18 %M=M*100;
19 disp(%M, 'attenuation=')

```

Scilab code Exa 9.20 calculate error

```

1 // calculate error
2 clc;
3 d=1;
4 At=(%pi*d^2)*10^-6/4;
5 V=100*10^-6;
6 h=30*10^-3;
7 P1=(At*h^2)/V;
8 P2=(At*h^2)/(V-At*h);
9 e=P2-P1;
10 disp(e, 'error=')

```
