Scilab Textbook Companion for Modern Electronic Instrumentation And Measurement Techniques by A. D. Helfrick And W. D. Cooper[1]

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Book Description

Title: Modern Electronic Instrumentation And Measurement Techniques

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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

Measurement and Error

Scilab code Exa 1.1 To find Average voltage Range of error

```
// To find Average voltage Range of error
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt . Ltd . India
// Example 1-1 in Page 3


clear; clc; close;

// Given data
E_1 = 117.02; // Voltage observed by 1st observer is
    117.02V
E_2 = 117.11; // Voltage observed by 2nd observer is
    117.11V
E_3 = 117.08; // Voltage observed by 3rd observer is
    117.08V
E_4 = 117.03; // Voltage observed by 4th observer is
    117.03V

```

```
//Calculations
E_av = (E_1+E_2+E_3+E_4)/4;
printf("(a)  The average voltage , E_av = %0.2f V\n "
   ,E_av);

E_max = max (E_1,E_2,E_3,E_4); // Maximum value
   among the 4 nos
E_min = min (E_1,E_2,E_3,E_4); // Minimum value
   among the 4 nos

range_1 = E_max - E_av; // Range calculated using
   two different formulae
range_2 = E_av - E_min; // Range calculated using
   two different formulae

avg_range = (range_1+range_2)/2
printf("(b)  The average range of error = +/- %0.2f
   V",avg_range);

//Result
// (a)  The average voltage , E_av = 117.06 V
// (b)  The average range of error = +/- 0.05 V
```

Scilab code Exa 1.2 To find Total resistance

```
// To find Total resistance
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-2 in Page 4

```

```
clear; clc; close;

// Given data
R_1 = 18.7; // The first resistance is 18.7ohm
R_2 = 3.624; // The second resistance is 3.624ohm

// Calculations
R_T = R_1 + R_2; // formula to calculate total
    resistance in series
printf("The total resistance connected in series =
    %0.3f ohm\n",R_T);
printf("As one of the resistance is accurate to only
     tenths of an ohm, The result should be reduced
    to the nearest tenth. \n Hence ")
printf("the total resistance is = %0.1f ohm",R_T);

//Result
// The total resistance connected in series = 22.324
     ohm
// As one of the resistance is accurate to only
    tenths of an ohm, The result should be reduced to
     the nearest tenth.
// Hence the total resistance is = 22.3 ohm
```

Scilab code Exa 1.3 To find voltage drop across resistor

```
// To find voltage drop across resistor
// Modern Electronic Instrumentation And Measurement
     Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
```

```
// Example 1-3 in Page 4


clear; clc; close;

// Given data
I = 3.18; //Current flowing through the resistor = 3.18A
R = 35.68; // The value of resistor = 35.68ohm

// Calculations
E = I*R;
printf("The voltage drop across the resistor = %0.4f volts",E);
disp('Since there are 3 significant figures involved in the multiplication, the result can be written only to a max of 3 significant figures');
printf("Hence the voltage drop across the resistor = %0.0f volts",E);

//Result
// The voltage drop across the resistor = 113.4624 volts
// Since there are 3 significant figures involved in the multiplication, the result can be written only to a max of 3 significant figures
// Hence the voltage drop across the resistor = 113 volts
```

Scilab code Exa 1.4 To find sum with range of doubt

```
// To find sum with range of doubt
// Modern Electronic Instrumentation And Measurement
```

```
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt . Ltd . India
// Example 1−4 in Page 5


clear; clc; close;

// Given data
// let N_1 = X_1 +/− Y_1
//      N_2 = X_2 +/− Y_2
X_1 = 826;
Y_1 = 5;
X_2 = 628;
Y_2 = 3;

//Calculations
X = (X_1 + X_2);
Y = (Y_1 + Y_2);
printf("SUM = %d +/− %d\n",X,Y);
%doubt = Y/X*100;
printf("The percentage range of doubt = +/−%0.2f%%",
   %doubt);

//Result
// SUM = 1454 +/− 8
// The percentage range of doubt = +/−0.55%
```

Scilab code Exa 1.5 To find difference with range of doubt

```
// To find difference with range of doubt
// Modern Electronic Instrumentation And Measurement
```

```
    Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-5 in Page 5


clear; clc; close;

// Given data
// let N_1 = X_1 +/- Y_1
//     N_2 = X_2 +/- Y_2
X_1 = 826;
Y_1 = 5;
X_2 = 628;
Y_2 = 3;

//Calculations
X = (X_1 - X_2);
Y = (Y_1 + Y_2);
printf("Difference = %d +/- %d\n",X,Y);
%doubt = Y/X*100;
printf("The percentage range of doubt = +/-%0.2f%%",
    %doubt);

//Result
// Difference = 198 +/- 8
// The percentage range of doubt = +/-4.04%
```

Scilab code Exa 1.6 To find difference with range of doubt

```
// To find difference with range of doubt
// Modern Electronic Instrumentation And Measurement
```

```
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-6 in Page 5


clear; clc; close;

// Given data
// let N_1 = X_1 +/- Y_1
//     N_2 = X_2 +/- Y_2
X_1 = 462;
Y_1 = 4;
X_2 = 437;
Y_2 = 4;

//Calculations
X = (X_1 - X_2);
Y = (Y_1 + Y_2);
printf("Difference = %d +/- %d\n",X,Y);
%doubt = Y/X*100;
printf("The percentage range of doubt = +/-%0.2f%%",
   %doubt);

//Result
// Difference = 25 +/- 8
// The percentage range of doubt = +/-32.00%
```

Scilab code Exa 1.7 To find Apparent and actual resistance

```
// To find Apparent and actual resistance
// Modern Electronic Instrumentation And Measurement
```

```
Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-7 in Page 6


clear; clc; close;

// Given data
I_T = 5*(10^-3); // Reading of the milliammeter in ampere
V_T = 100; // Reading of the voltmeter in volt
sensitivity = 1000; // sensitivity of voltmeter in ohm/volt
scale = 150; // scale of the voltmeter

//Calculations
R_T = V_T / I_T; // formula to calculate total circuit resistance
printf("(a) The apparent circuit resistance neglecting the resistance of milliammeter, R_T = %d ohm\n",R_T);

R_V = sensitivity * scale; // calculating resistance of voltmeter
R_X = (R_T * R_V)/(R_V - R_T); // effective circuit resistance due to loading effect
printf("(b) The actual circuit resistance with the loading effect of voltmeter, R_X = %0.2f ohm\n",R_X);

percentage_error = (R_X - R_T)*100/ R_X;
// %error = (actual-apparent)/ actual
printf("(c) The percentage error due to loading effect of voltmeter = %0.2f%%",percentage_error);

//result
```

```
// (a)  The apparent circuit resistance neglecting the resistance of milliammeter, R_T = 20000 ohm
// (b)  The actual circuit resistance with the loading effect of voltmeter, R_X = 23076.92 ohm
// (c)  The percentage error due to loading effect of voltmeter = 13.33%


// The result shown in the textbook is printed incorrectly and does not match with the correct result
```

Scilab code Exa 1.8 To find Apparent and actual resistance

```
// To find Apparent and actual resistance
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-8 in Page 7


clear; clc; close;

// Given data
I_T = 800*(10^-3); // Reading of the milliammeter in ampere
V_T = 40; // Reading of the voltmeter in volt
sensitivity = 1000; // sensitivity of voltmeter in ohm/volt
scale = 150; // scale of the voltmeter

```

```
//Calculations
R_T = V_T / I_T; // formula to calculate total circuit resistance
printf("(a) The apparent circuit resistance neglecting the resistance of milliammeter, R_T = %0.2f ohm\n",R_T);

R_V = sensitivity * scale; // calculating resistance of voltmeter
R_X = (R_T * R_V)/(R_V - R_T); // effective circuit resistance due to loading effect
printf("(b) The actual circuit resistance with the loading effect of voltmeter, R_X = %0.2f ohm\n",R_X);

percentage_error = (R_X - R_T)*100/ R_X;
// %error = (actual-apparent)/ actual
printf("(c) The percentage error due to loading effect of voltmeter = %0.2f%%",percentage_error);

//result
// (a) The apparent circuit resistance neglecting the resistance of milliammeter, R_T = 50.00 ohm
// (b) The actual circuit resistance with the loading effect of voltmeter, R_X = 50.02 ohm
// (c) The percentage error due to loading effect of voltmeter = 0.03%


// The result shown in the textbook is printed incorrectly and does not match with the correct result
```

Scilab code Exa 1.9 To find Arithmatic mean and deviation from mean

```
// To find Arithmatic mean and deviation from mean
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-9 in Page 9


clear; clc; close;

// Given data
// Independent current measurements taken by six
   observers
I_1 = 12.8*(10^-3);
I_2 = 12.2*(10^-3);
I_3 = 12.5*(10^-3);
I_4 = 13.1*(10^-3);
I_5 = 12.9*(10^-3);
I_6 = 12.4*(10^-3);

//Calculations
arithmatic_mean = (I_1 +I_2 +I_3 +I_4 +I_5 +I_6)/6;
printf("(a)  The arithmatic mean of the observations
    =%0.5f A",arithmatic_mean);

d_1 = I_1 - arithmatic_mean;
d_2 = I_2 - arithmatic_mean;
d_3 = I_3 - arithmatic_mean;
d_4 = I_4 - arithmatic_mean;
d_5 = I_5 - arithmatic_mean;
d_6 = I_6 - arithmatic_mean;

//deviation calculated using the formula d_n = x_n -
    arithmatic_mean
disp('(b)  The deviations from the mean are:' );
```

```
printf("d_1 = %0.5f A\n d_2 = %0.5f A\n d_3 = %0.5f
    A\n d_4 = %0.5f A\n d_5 = %0.5f A\n d_6 = %0.5f A
    \n",d_1, d_2, d_3, d_4, d_5, d_6);

//Result
// (a) The arithmatic mean of the observations
    =0.01265 A
// (b) The deviations from the mean are:
// d_1 = 0.00015 A
// d_2 = -0.00045 A
// d_3 = -0.00015 A
// d_4 = 0.00045 A
// d_5 = 0.00025 A
// d_6 = -0.00025 A
```

Scilab code Exa 1.10 To find Average deviation

```
// To find Average deviation
// Modern Electronic Instrumentation And Measurement
     Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-10 in Page 10


clear; clc; close;

// Given data
// These are the data found out from the example_1-9
d_1 = 0.000150;
d_2 = -0.000450;
d_3 = -0.000150;
```

```
d_4 = 0.000450;
d_5 = 0.000250;
d_6 = -0.000250;

//Calculation
D = (abs(d_1) +abs(d_2) +abs(d_3) +abs(d_4) +abs(d_5
   ) +abs(d_6))/6;
printf("The average deviation , D = %0.2e A",D);

//Result
//  The average deviation , D = 2.83e-004 A
```

Scilab code Exa 1.11 To find Std deviation and Probable error

```
// To find Std deviation and Probable error
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-11 in Page 14


clear; clc; close;

// Given data
// let the 10 resistance measurements in ohm be
   taken as elements of matrix
x = [101.2 101.7 101.3 101.0 101.5 101.3 101.2 101.4
    101.3 101.1];

//Calculations
arithmatic_mean = mean(x);
```

```
sigma = st_deviation(x);
probable_error = 0.6745 * sigma;
printf("(a)  The arithmatic mean of the readings =
   %0.1f ohm\n",arithmatic_mean);
printf("(b)  The standard deviation of the readings
   = %0.1f ohm\n",sigma);
printf("(c)  The probable error of the readings = %0
   .4f ohm",probable_error);

//Result
// (a)  The arithmatic mean of the readings = 101.3
   ohm
// (b)  The standard deviation of the readings = 0.2
    ohm
// (c)  The probable error of the readings = 0.1349
   ohm
```

Scilab code Exa 1.12 To find Limiting error

```
// To find Limiting error
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-12 in Page 14


clear; clc; close;

// Given data
scale = 150;
percentage_accuracy = 1/100; // accuracy of 1% full
```

```
    scale reading
V = 83; //voltage measured by instrument = 83 volt

//Calculations
limiting_error = percentage_accuracy * scale;
printf("The magnitude of the limiting error = %0.1f
   V\n",limiting_error);

percentage_error = limiting_error/V * 100;
printf("The percentage limiting error = %0.2f
    percent",percentage_error);

//Result
// The magnitude of the limiting error = 1.5 V
// The percentage limiting error = 1.81 percent
```

Scilab code Exa 1.13 To find the maximum error

```
// To find the maximum error
// Modern Electronic Instrumentation And Measurement
     Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-13 in Page 15


clear; clc; close;

// Given data
// For the given tolerence of 0.1%
// highest value of resistor is 1.001 times the
    nominal value
```

```
// lowest value of resistor is 0.999 times the
   nominal value

//Calculations
V_out_max = 1.001 * 1.001/ 0.999;
V_out_min = 0.999 * 0.999/ 1.003;
total_var = 0.1 * 3; // total variation of the
   resultant voltage is sum of tolerences
printf("The total variation of the resultant voltage
    = +/- %0.1f %%",total_var);

//Result
// The total variation of the resultant voltage =
   +/- 0.3 %
```

Scilab code Exa 1.14 To find limiting error

```
// To find limiting error
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 1-14 in Page 16


clear; clc; close;

// Given data
// let I = X_1 +/- Y_1
//     R = X_2 +/- Y_2
X_1 = 2.00;
Y_1 = 0.5;
```

```
X_2 = 100;
Y_2 = 0.2;

//Calculations
P_1 = ((1+0.005)^2)*(1+0.002);
printf("For the worst possible combination of the values of current and resistance,\nThe highest power dissipation becomes,\n");
printf("P = %0.3f (I^2)*R Watts\n",P_1);
P_2 = ((1-0.005)^2)*(1-0.002);
printf("For the lowest power dissipation.\nP = %0.3f (I^2)*R Watts\n",P_2)
lim_error = 2 * Y_1 + Y_2;
printf("The limiting error = +/- %0.1f%%",lim_error);

//Result
// For the worst possible combination of the values of current and resistance,
// The highest power dissipation becomes,
// P = 1.012 (I^2)*R Watts
// For the lowest power dissipation.
// P = 0.988 (I^2)*R Watts
// The limiting error = +/- 1.2%
```

Chapter 2

Systems of Units of Measurement

Scilab code Exa 2.1 To convert area in metre to feet

```
// To convert area in metre to feet
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 2-1 in Page 29

clear; clc; close;

// Given data
A_m = 5000; // area in metre^2 unit

//Calculation
A_ft = A_m * (1/0.3048)^2; // As 1ft = 0.3048m
printf("The area in feet = %d sq.ft",round(A_ft));

//Result
// The area in feet = 53820 sq.ft
```

Scilab code Exa 2.2 To convert flux density to different units

```
// To convert flux density to different units
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 2-2 in Page 29

clear; clc; close;

// Given data
B_cm = 20; // flux density in maxwell/sq.cm

//Calculations

B_in = B_cm *2.54^2; // converting to lines/sq.inch
printf("The flux density in lines/sq.in = %d lines/(
    in^2)",B_in);

//Result
// The flux density in lines/sq.in = 129 lines/(in
    ^2)
```

Scilab code Exa 2.3 To convert velocity to a different unit

```
// To convert velocity to a different unit
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 2−3 in Page 29

clear; clc; close;

// Given data
c_s = 2.997925 * 10^8; // velocity in m/s

//Calculations
c_hr = 2.997925 *10^8* 1/10^3* 3.6*10^3; // velocity in km/hr
printf("The velocity of light in km/hr = %0.3e km/hr ",c_hr);

//Result
// The velocity of light in km/hr = 1.079e+009 km/hr
```

Scilab code Exa 2.4 To convert density to a different unit

```
// To convert density to a different unit
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 2−4 in Page 29

clear; clc; close;
```

```

// Given data
Density_ft = 62.5;

//Calcualtions
Density_in = 62.5 * (1/12)^3;
Density_cm = Density_in * 453.6 * (1/2.54)^3;
printf("(a)  The density of water in lb/cubic inch =
    %f lb/(in^3).\n",Density_in);
printf("(b)  The density of water in g/cubic cm = %f
    g/(cm^3).",Density_cm);

//Result
// (a)  The density of water in lb/cubic inch =
   0.036169 lb/(in^3).
// (b)  The density of water in g/cubic cm =
   1.001171 g/(cm^3).
```

Scilab code Exa 2.5 To convert speed limit to a different unit

```
// To convert speed limit to a different unit
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 2-5 in Page 30

clear; clc; close;

// Given data
speed_km = 60; // speed limit in km/hr

```

```
//Calculations
speed_m = 60 *10^3 *10^2 *(1/2.54) *(1/12)*(1/5280);
speed_ft = 37.3 *5280 *(1/(3.6*10^3));

printf("(a)  The speed limit in m/hr = %0.1f mi/hr\n",speed_m);
printf("(b)  The speed limit in ft/s = %0.1f ft/s",speed_ft);

//Result
// (a)  The speed limit in m/hr = 37.3 mi/hr
// (b)  The speed limit in ft/s = 54.7 ft/s


//The answer given in textbook is printed incorrectly and does not match with calculated answer
```

Chapter 4

Electromechanical Indicating Instruments

Scilab code Exa 4.1 To find Shunt resistance required

```
// To find Shunt resistance required
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 4-1 in Page 56


clear; clc; close;

// Given data
I_m = 1*(10^-3); //Full scale deflection of the
   movement in ampere
R_m = 100; //Internal resistance of the movement(the
    coil) in ohm
I = 100*(10^-3); //Full scale of the ammeter
   including the shunt in Ampere

```

```
//Calculations
I_s = I - I_m; // calculating current through shunt
R_s = I_m * R_m/ I_s; //calculating shunt to be added
printf("The value of the shunt resistance required, R_s = %0.2f ohm",R_s);

//Result
// The value of the shunt resistance required, R_s = 1.01 ohm
```

Scilab code Exa 4.2 To design Ayrton shunt

```
// To design Ayrton shunt
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 4-2 in Page 57


clear; clc; close;

// Given data
I_1 = 1; //Full scale currents of the ammeter in amp
I_2 = 5;
I_3 = 10;
R_m = 50; //Internal resistance of the movement(the coil) in ohm
I_m = 1*(10^-3); //Full scale deflection of the movement in ampere

```

```
//Calculations
// On the 1-A range:
I_s1 = I_1 - I_m; // calculating current through shunt
//Using the eq. R_s = I_m * R_m/ I_s
//1                    R_a +R_b +R_c = I_m * R_m/ I_s; // As (R_a +R_b +R_c) are parallel with R_m

// On the 5-A range
I_s2 = I_2 - I_m;
//2                    R_a +R_b = I_m * (R_c +R_m)/ I_s; // As (R_a+R_b) in parallel with (R_c+R_m)

// On the 10-A range
I_s3 = I_3 - I_m;
//3                    R_a = I_m * (R_b +R_c +R_m)/ I_s; // As R_a is parallel with (R_b +R_c +R_m)


//Solving the 3 simultaneous linear equations
function y = rr(R);
y(1)= R(1) +R(2) +R(3) - (I_m * R_m/ I_s1);
y(2)= R(1) +R(2) -(I_m * (R(3) +R_m)/ I_s2);
y(3)= R(1) -(I_m * (R(2) +R(3) +R_m)/ I_s3);
endfunction

answer = fsolve([0.1;0.1;0.1],rr);
R_a = answer([1]);
R_b = answer([2]);
R_c = answer([3]);

disp('The different resistors used for the ayrton shunt for different ranges are:');
printf("R_a = %f ohm\n",R_a);
printf("R_b = %f ohm\n",R_b);
printf("R_c = %f ohm",R_c);
```

```
//Result
// The different resistors used for the ayrton shunt
    for different ranges are:
// R_a = 0.005005 ohm
// R_b = 0.005005 ohm
// R_c = 0.040040 ohm
```

Scilab code Exa 4.3 To design multirange dc voltmeter

```
// To design multirange dc voltmeter
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 4-3 in Page 60


clear; clc; close;

// Given data
R_m = 100; // internal resistance of movement
I_fsd = 1*(10^-3); //full-scale current in Amp
V_1 = 10; //different ranges in volt
V_2 = 50;
V_3 = 250;
V_4 = 500;

//Calculations

//For the 10-V range
R_T = V_1 / I_fsd;
```

```
R_4 = R_T - R_m;
printf("The value of the resistance R_4 = %d ohm\n",R_4);

//For the 50-V range
R_T = V_2 / I_fsd;
R_3 = R_T - (R_4 +R_m);
printf("The value of the resistance R_3 = %dk ohm\n",R_3/1000);

//For the 250-V range
R_T = V_3 / I_fsd;
R_2 = R_T -(R_3 +R_4 +R_m);
printf("The value of the resistance R_2 = %dk ohm\n",R_2/1000);

//For the 500-V range
R_T = V_4 / I_fsd;
R_1 = R_T - (R_2 +R_3 +R_4 +R_m);
printf("The value of the resistance R_1 = %dk ohm",R_1/1000);

//Result
// The value of the resistance R_4 = 9900 ohm
// The value of the resistance R_3 = 40k ohm
// The value of the resistance R_2 = 200k ohm
// The value of the resistance R_1 = 250k ohm
```

Scilab code Exa 4.4 To design multirange dc voltmeter

```
// To design multirange dc voltmeter
// Modern Electronic Instrumentation And Measurement Techniques
```

```
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt . Ltd . India
// Example 4-4 in Page 62


clear; clc; close;

// Given data
// This is a repitition of example_4-3 with
    sensitivity method
R_m = 100; // internal resistance of movement
I_fsd = 1*(10^-3); //full-scale current in Amp
V_1 = 10; //different ranges in volt
V_2 = 50;
V_3 = 250;
V_4 = 500;

//Calculations
S = 1/ I_fsd; // sensitivity in ohm/V
R_4 = (S * V_1)-R_m;
R_3 = (S * V_2)-(R_4 +R_m);
R_2 = (S * V_3)-(R_3 +R_4 +R_m);
R_1 = (S * V_4)-(R_2 +R_3 +R_4 +R_m);

printf("The value of the resistance R_4 = (%dohm/V *
   %dV)- %dohm = %d ohm\n",S,V_1,R_m,R_4);
printf("The value of the resistance R_3 = (%dohm/V *
   %dV)- %dohm = %dK ohm\n",S,V_2,(R_4+R_m),R_3
   /1000);
printf("The value of the resistance R_2 = (%dohm/V *
   %dV)- %dohm = %dK ohm\n",S,V_3,(R_3 +R_4 +R_m),
   R_2/1000);
printf("The value of the resistance R_1 = (%dohm/V *
   %dV)- %dohm = %dK ohm",S,V_4,(R_2 +R_3 +R_4 +R_m
   ),R_1/1000);

//Result
```

```
// The value of the resistance R_4 = (1000ohm/V *10V
    )- 100ohm  = 9900 ohm
// The value of the resistance R_3 = (1000ohm/V *50V
    )- 10000ohm  = 40K ohm
// The value of the resistance R_2 = (1000ohm/V *250
    V)- 50000ohm  = 200K ohm
// The value of the resistance R_1 = (1000ohm/V *500
    V)- 250000ohm  = 250K ohm
```

Scilab code Exa 4.5 To find voltage reading and Error

```
// To find voltage reading and Error
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 4-5 in Page 62

clear; clc; close;

// Given data
// resistances in series
R_1 = 100 * 10^3;
R_2 = 50 *10^3;
// sensitivity of two voltmeters
S_1 = 1000;
S_2 = 20000;
V = 50; // range of the voltmeters
E = 150; // voltage of battery in volt

//Calculations
//By voltage divider rule
```

```
V_true = R_2 /(R_1+R_2)*E;
printf("The true voltage across resistor R_2 = %d V\n",V_true);

//Reading of the first voltmeter
R_T1 = S_1 * V; // resistance of voltmeter = sensitivity * range
R_p =(R_2 *R_T1)/(R_2 +R_T1)// effective parallel resistance
R_c1 = R_1+R_p  // The total circuit resistance
V_1 = 25*10^3/R_c1 *E;
printf("The reading of the first voltmeter = %d V\n",V_1);

//Reading of the second voltmeter
R_T2 = S_2 * V; // resistance of voltmeter = sensitivity * range
R_p =(R_2 *R_T2)/(R_2 +R_T2)
R_c2 = R_1 +R_p // The total circuit resistance
V_2 = 47.6*10^3/R_c2 *E;
printf("The reading of the second voltmeter = %0.2f V\n",V_2);

%error_1 = (V_true - V_1)/V_true *100;
printf("The error in the reading due to voltmeter 1 =%d%%\n",%error_1);
%error_2 = (V_true - V_2)/V_true *100;
printf("The error in the reading due to voltmeter 2 =%0.2f%%",%error_2);

//Results
// The true voltage across resistor R_2 = 50 V
// The reading of the first voltmeter = 30 V
// The reading of the second voltmeter = 48.37 V
// The error in the reading due to voltmeter 1 =40%
// The error in the reading due to voltmeter 2 =3.26%

```

```
//The answers are varying as approximation is not
   done
```

Scilab code Exa 4.6 To find the value of unknown resistor

```
// To find the value of unknown resistor
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt . Ltd . India
// Example 4-6 in Page 64


clear; clc; close;

// Given data
S = 100; //Sensitivity of the voltmeter
// Three ranges of the voltmeter
V_1 = 50;
V_2 = 150;
V_3 = 300;
V_p = 4.65; //Reading of the meter on its 50-V scale
R_s = 100*10^3;
E = 100; //emf applied in volt
//Calculations
R_V = S * V_1;
R_p = ceil(V_p *R_s/ (E -V_p)); //R_p is the
   parallel resistance of R_x and R_v
R_x = R_p *R_V/ (R_V -R_p);
printf("The value of the unknown resistance R_x = %0
   .1e ohm",ceil(R_x));

```

```
//Result
// The value of the unknown resistance R_x = 2.0e+005 ohm
```

Scilab code Exa 4.7 To find the scale error

```
// To find the scale error
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 4-7 in Page 67


clear; clc; close;

// Given data
R_h = 2000; //The desired scale marking for the half scale deflection
E = 3; //The internal battery voltage in volt
I_fsd = 1 *(10^-3); //Current for full scale deflection in ampere
R_m = 50; //resistance of the basic movement in ohm

//Calculations
I_t = E / R_h; //Total battery current at FSD
I_2 = I_t - I_fsd; // Current through zero-adjust resistor R_2
R_2 = I_fsd * R_m/I_2;
R_p = R_2*R_m/(R_2 + R_m);
R_1 = R_h - R_p;
printf("(a)  The value of R_1 and R_2 is")
```

```
printf("The value of zero-adjust resistor R2 =%0.1f ohm\n",R_2);
printf("The value of current-limiting resistor R1 =%0.1f ohm\n",R_1);

//At a 10% drop in battery voltage
E = 3- 0.3;
I_t = E / R_h; //Total battery current in A
I_2 = I_t - I_fsd; //Shunt current in A
R_2 = ceil(I_fsd * R_m/I_2);
R_p = R_2 *R_m/(R_2+R_m);
R_h = R_1 + R_p;
%error = (2000-2003.7)/2003.7*100;
printf("\n(b)  The maximum value of R2 to compensate the drop in battery voltage = %d ohm\n",R_2);
printf("The true value of the half-scale mark on the meter is = %0.3f ohm\n",R_h);
printf("\n(c)  The percentage error = %0.3f%%\n",%error);
disp('The negative sign indicates that the meter reading is low');

//Result
// (a)  The value of R_1 and R_2 isThe value of zero-adjust resistor R2 =100.0 ohm
// The value of current-limiting resistor R1 =1966.7 ohm

// (b)  The maximum value of R2 to compensate the drop in battery voltage = 143 ohm
// The true value of the half-scale mark on the meter is = 2003.713 ohm

// (c)  The percentage error = -0.185%

// The negative sign indicates that the meter reading is low
```

Scilab code Exa 4.8 To find shunt and current limiting resistor

```
// To find shunt and current limiting resistor
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 4-8 in Page 70


clear; clc; close;

// Given data
I_fsd = 10*(10^-3); // current for full scale deflection in ampere
R_m = 5; //internal resistance of the d'Arsonval movement in ohm
E = 3; //Battery voltage in volt
R_h = 0.5; //The desired scale marking for the half scale deflection in ohm

//Calculations
I_m = 0.5 * I_fsd; // Current for half scale deflection of movement
E_m = I_m * R_m; //The voltage across movement
I_x = E_m / R_h; // Voltage across unknown resistor R_x
I_sh = I_x - I_m; //As I_x = I_sh + I_m
R_sh = E_m / I_sh;
I_t = I_m +I_sh +I_x; //The total battery current
R_1 = (E - E_m)/I_t;
```

```
printf("(a)  The value of the shunt resistor, R_sh = %0.3f ohm\n",R_sh);
printf("(b)  The value of the current limiting resistor, R_1 = %0.2f ohm",R_1);

//Result
// (a)  The value of the shunt resistor, R_sh = 0.556 ohm
// (b)  The value of the current limiting resistor, R_1 = 29.75 ohm
```

Scilab code Exa 4.9 To find multiplier resistor

```
// To find multiplier resistor
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 4-9 in Page 79


clear; clc; close;

// Given data
R_m = 50; //Internal resistance of the movement in ohm
I_fsd = 1 *(10^-3); //current for full scale deflection in ampere
E_rms = 10; // AC voltage applied to input terminals in volt

//Calculation
```

```
disp('Assuming zero forward resistance and infinite
    reverse resistance');
E_dc = round(2 *sqrt(2)*E_rms/%pi);
R_t = E_dc / I_fsd; //Total circuit resistance
R_s = R_t - R_m; //Calculating multiplier resistor
printf("The value of the multiplier resistor , R_s =
   %d ohm",R_s);

//Result
// Assuming zero forward resistance and infinite
    reverse resistance
// The value of the multiplier resistor , R_s = 8950
   ohm
```

Scilab code Exa 4.10 To find voltmeter sensitivity on AC range

```
// To find voltmeter sensitivity on AC range
// Modern Electronic Instrumentation And Measurement
     Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt . Ltd . India
// Example 4-10 in Page 81


clear; clc; close;

// Given data
R_m = 100; //Internal resistance of the movement in
   ohm
R_sh = 100;
I_fsd = 1*(10^-3); //current for full scale
    deflection
```

```
R_D1 = 400;
R_D2 = 400;
E_rms = 10; //AC range of the voltmeter

//Calculations
disp('Assuming infinite reverse resistance');
I_t = 2 *I_fsd;
E_dc = 0.45 * E_rms;
R_t = E_dc / I_t;
R_p = R_m *R_sh/(R_m+R_sh);
R_s = R_t - (R_D1 + R_p);
printf("(a) The value of the multiplier resistor
    required , R_s = %d ohm\n",R_s);
S = R_t / E_rms;
printf("(b) The sensitivity of the voltmeter on ac
    range , S = %d ohm/V",S);

//Result
// Assuming infinite reverse resistance
// (a) The value of the multiplier resistor
    required , R_s = 1800 ohm
// (b) The sensitivity of the voltmeter on ac range
    , S = 225 ohm/V
```

Chapter 5

Bridge Measurements

Scilab code Exa 5.1 To find deflection caused by the given unbalance

```
// To find deflection caused by the given unbalance
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 5-1 in Page 101


clear; clc; close;

// Given data
// Resistances of the 4 arms in ohm
R_1 = 1000;
R_2 = 100;
R_3 = 200;
R_4 = 2005;

E = 5; // battery EMF in volt
S_I = 10*(10^-3)/(10^-6); //Current sensitivity in m
    /A
```

```
R_g = 100; //Internal resistance of galvanometer in ohm

//Calculations

//Calculations are made wrt fig 5-3 in page 103
//Bridge balance occurs if arm BC has a resistance of 2000 ohm. The diagram shows arm BC has as a resistance of 2005 ohm

//To calculate the current in the galvanometer, the ckt is thevenised wrt terminals B and D.
//The potenttial from B to D, with the galvanometer removed is the Thevenin voltage

// E_TH = E_AD - E_AB

E_TH = E * ((R_2/(R_2+R_3)) - (R_1/ (R_1+R_4)));
R_TH = ((R_2 * R_3/(R_2+R_3)) + (R_1 * R_4/ (R_1+R_4)));

//When the galvanometer is now connected to the output terminals, The current through the galvanometer is

I_g = E_TH /(R_TH +R_g);
d = I_g * S_I;
printf("The deflection of the galvanometer = %0.2f mm",(d*1000));

//Result
// The deflection of the galvanometer = 33.26 mm
```

Scilab code Exa 5.2 To check the capability of detecting unbalance

```
// To check the capability of detecting unbalance
// Modern Electronic Instrumentation And Measurement
   Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt . Ltd . India
// Example 5−2 in Page 102


clear; clc; close;

// Given data
// Resistances of the 4 arms in ohm
R_1 = 1000;
R_2 = 100;
R_3 = 200;
R_4 = 2005;

E = 5; // battery EMF in volt
S_I = 1*(10^-3)/(10^-6); //Current sensitivity in m/
   A
R_g = 500; //Internal resistance of galvanometer in
   ohm




//Calculations

//Calculations are made wrt fig 5−3 in page 103
//Bridge balance occurs if arm BC has a resistance
   of 2000 ohm. The diagram shows arm BC has as a
   resistance of 2005 ohm

//To calculate the current in the galvanometer , the
   ckt is thevenised wrt terminals B and D.
```

```
//The potenttial from B to D, with the galvanometer removed is the Thevenin voltage

// E_TH = E_AD - E_AB

E_TH = E * ((R_2/(R_2+R_3)) - (R_1/ (R_1+R_4)));
R_TH = ((R_2 * R_3/(R_2+R_3)) + (R_1 * R_4/ (R_1+R_4)));

//When the galvanometer is now connected to the output terminals , The current through the galvanometer is

I_g = E_TH /(R_TH +R_g);
d = I_g * S_I;
printf("The deflection of the galvanometer = %0.3f mm",d*1000);
disp('Given that galvanometer is capable of detecting a deflection of 1mm');
disp('Hence looking at the result ,it can be seen that this galvanometer produces a deflection that can be easily observed');

//Result
// The deflection of the galvanometer = 2.247 mm
// Given that galvanometer is capable of detecting a deflection of 1mm

// Hence looking at the result ,it can be seen that this galvanometer produces a deflection that can be easily observed
```

Scilab code Exa 5.3 To find the unknown impedence

```
// To find the unknown impedence
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 5-3 in Page 111


clear; clc; close;

// Given data
// The given polar forms in textbook is represented in rect form
Z_1 = 17.36482 +%i *98.48078;
Z_2 = 250;
Z_3 = 346.4102 +%i *200;

//Calculations
//The first condition for bridge balance is Z_1*Z_4 = Z_2*Z_3
mod_Z_4 = (abs(Z_2) *abs(Z_3)/abs(Z_1));

//The second condition for bridge balance requires that sum of the phase angles of opposite arms be equal
theta_Z_4 = (atan(imag(Z_2),real(Z_2)) +atan(imag(Z_3),real(Z_3)) -atan(imag(Z_1),real(Z_1)))*180/%pi;

printf("The impedence of the unknown arm = %d ohm /_%d deg\n",mod_Z_4,theta_Z_4);
printf("Here the magnitude of impedence is 1000 and phase angle is 50 in degrees\n");
printf("The above value indicates that we are dealing with a capacitive element, possibly consisting of a series combination of a resistor and capacitance");
```

```

//Result
// The impedence of the unknown arm = 1000 ohm /_ -50 deg
// Here the magnitude of impedence is 1000 and phase angle is 50 in degrees
// The above value indicates that we are dealing with a capacitive element, possibly consisting of a series combination of a resistor and capacitance
```

Scilab code Exa 5.4 To find the unknown impedence

```
// To find the unknown impedence
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 5-4 in Page 112


clear; clc; close;

// Given data
// The notations are wrt to the figure 5-10 in page 109

//Arm AB
R_1 = 450;
//Arm BC
R_2 = 300;
C = 0.265 *(10^-6);
```

```
//Arm DA
R_3 = 200;
L = 15.9*(10^-3);
f = 1000;

//Calculations
w = 2*%pi*f;
Z_1 = 450;
Z_2 = R_2 - %i *floor(1/(w*C));
Z_3 = R_3 + %i*ceil(w*L);

Z_4 = Z_1*Z_3/Z_2;
printf("The impedence of the unknown arm = %di ohm\n",imag(Z_4));
printf("The result indicates that Z_4 is a pure inductance with an inductive reactance of 150 ohm at a frequency of 1 khz.\n")

L_ans = imag(Z_4)/w;
printf("The inductance present in the arm CD = %0.1fm H",L_ans*1000);

//Result
// The impedence of the unknown arm = 150i ohm
// The result indicates that Z_4 is a pure inductance with an inductive reactance of 150 ohm at a frequency of 1 khz.
// The inductance present in the arm CD = 23.9m H
```

Scilab code Exa 5.5 To balance the unbalanced bridge

```
// To balance the unbalanced bridge
// Modern Electronic Instrumentation And Measurement
```

```
Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 5-5 in Page 119


clear; clc; close;

// Given data
Z_1 = -1000*%i;
Z_2 = 500;
Z_3 = 1000;
Z_4 = 100+500*%i;

// The balance is not possible with this condition as theta_1+theta_4 will be slightly negative than theta_2+theta3
// Balance can be achieved by 2 methods:
disp('First option is to modify Z_1 so that its phase angle is decreased to less than 90deg by placing a resistor in parallel with the capacitor.')
// The resistance R_1 can be determined by the standard approach

//Calculations
Y_1 = Z_4/(Z_2*Z_3);
//Also,
// Y_1 = (1/R) + %i/1000;
// equating both the equations and solving for R_1

R_1 = 1/(Y_1-(%i/1000 ));
printf("The value of the resistor R_1 in parallel with capacitor = %d ohm\n",R_1);

// It should be noted that the addition of R_1 upsets the first balance condition as the
```

```
magnitude of Z_1 is changed
// Hence the variable R_3 should be adjusted to compensate this effect
disp('The second option is to modify the phase angle of arm 2 or arm 3 by adding series capacitor');
Z_3_1 = Z_1 *Z_4/Z_2;
// substituting for the component values and solving for X_C yeilds
X_C = abs(1000- Z_3_1)/-%i;
printf("The value of the reactance of the capacitor used, X_C = %d ohm",imag(X_C));
//In this case the magnitude of the Z_3 is increased so that the first balance condition is changed
//A small adjustment of R_3 is necessary to restore balance
//Result
// First option is to modify Z_1 so that its phase angle is decreased to less than 90deg by placing a resistor in parallel with the capacitor.
// The value of the resistor R_1 in parallel with capacitor = 5000 ohm
// The second option is to modify the phase angle of arm 2 or arm 3 by adding series capacitor
// The value of the reactance of the capacitor used, X_C = 200 ohm
```

Chapter 6

Electronic Instruments for Measuring Basic Parameters

Scilab code Exa 6.1 To find the form factor and error

```
// To find the form factor and error
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 6-1 in Page 131


clear; clc; close;

// Given data
//let
E_m = 10; //Let the peak amplitude of the square
   wave be 10V
T = 1; //Let the time period of the square wave be 1
   s

function y= f(t),y=(E_m)^2 ,endfunction
```

```
E_rms = sqrt(1/T * intg(0,T,f));
printf("(a) The rms value of the square wave = %d V\n",E_rms);

function x = ff(t),x =(E_m) ,endfunction
E_av = (2/T * intg(0,T/2,ff));
printf(" The average value of the square wave = %d V\n",E_av);

k = E_rms/E_av;
printf(" The form factor of the square wave =%d\n",k);

k_sine = 1.11;
k_square = 1;
%error = (k_sine - k_square)/k_square*100;
printf("(b) The percentage error in meter indication = %d %%",%error);

//Result
// (a) The rms value of the square wave = 10 V
// The average value of the square wave = 10 V
// The form factor of the square wave =1
// (b) The percentage error in meter indication = 11 %
```

Scilab code Exa 6.2 To find the form factor and error

```
// To find the form factor and error
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
```

```
// Dorling Kindersly Pvt. Ltd. India
// Example 6-2 in Page 132


clear; clc; close;

// Given data
E_m = 150; //Let the peak amplitude of the sawtooth wave be 150V
T = 3; //Let the time period of the sawtooth wave be 3s
// e = 50*t; As seen from the figure 6-7b in page 131

//Calculations
function y= f(t),y=(50*t)^2 ,endfunction
E_rms = sqrt(1/T * intg(0,T,f));
printf("(a)  The rms value of the sawtooth wave = %d V \n",E_rms);

function x = ff(t),x =(50*t) ,endfunction
E_av = (1/T * intg(0,T,ff));
printf("The average value of the sawtooth wave = %d V\n",E_av);

k_st = E_rms/E_av;
printf("The form factor of the sawtooth wave =%0.3f\n",k_st);

k_sine = 1.11;
r = k_sine/k_st;
printf("(b)  The ratio of the two form factors = %0.3f\n",r);

printf("The meter indication is low by a factor of %0.3f\n",r);
%error = (r - 1)/1*100;
printf("The percentage error in meter indication =
```

```
%0.1f %%",%error);

//Result
// (a)  The rms value of the sawtooth wave = 86 V
// The average value of the sawtooth wave = 75 V
// The form factor of the sawtooth wave =1.155
// (b)  The ratio of the two form factors = 0.961
// The meter indication is low by a factor of 0.961
// The percentage error in meter indication = -3.9 %
```

Scilab code Exa 6.3 To find the maximum time

```
// To find the maximum time
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 6-3 in Page 144


clear; clc; close;

// Given data
R = 100*(10^3); // Value of resistance in ohm
C = 0.1*(10^-6); // The value of integrating
    capacitor in F
V_ref = 2; // The reference voltage in V
V_out = 10; // The maximum limit of the output in V

//Calculations
T = R*C;
printf("The integrator time constant = %0.3f s\n",T)
```

```
    ;
V_s = V_ref/T; //Unit is V/s
V = 1/V_s;
printf("Therefore the integrator output = %0.3f s/V"
    ,V)
disp('Therefore to integrate 10V');
T_max = V*V_out; //The max time the ref voltage can
    be integrated
printf("The time required = %0.4f s",T_max);

//Result
// The integrator time constant = 0.010 s
// Therefore the integrator output = 0.005 s/V
// Therefore to integrate 10V
// The time required = 0.0500 s
```

Scilab code Exa 6.4 To find the distributed capacitance

```
// To find the distributed capacitance
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 6-4 in Page 162


clear; clc; close;

// Given data
// Frequency measurements in Hz
f_1 = 2*10^6;
f_2 = 4*10^6;
```

```
// Value of tuning capacitor in F
C_1 = 460*10^-12;
C_2 = 100*10^-12;

//Calculations
 C_d = (C_1- (4*C_2))/3;
printf("C_d = %0.0E F\n",C_d);
printf("i.e The value of the distributed capacitance
    = %d pF",(C_d*10^12));

//Result
// C_d = 2E-011 F
// i.e The value of the distributed capacitance = 20
    pF
```

Scilab code Exa 6.5 To find the self capacitance

```
// To find the self capacitance
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 6-5 in Page 162


clear; clc; close;

// Given data
// Values of frequencies in Hz
f_1 = 2*10^6;
f_2 = 5*10^6;
// Values of the tuning capacitors in F
```

```
C_1 = 450*10^-12;
C_2 = 60*10^-12;

//Calculations

//Using the equation f = 1/(2*%pi*sqrt(L*(C_2+C_d)))
    ;
//Since f_2 = 2.5*f_1
//Equating & reducing the equations
// 1/(C_2 +C_d) = 6.25/(C_1 +C_d)

C_d = (C_1 -6.25*C_2)/5.25
printf("C_d = %0.2E F\n",C_d);
printf("i.e The value of the distributed capacitance
     = %0.1f pF",(C_d*10^12));

//Result
// C_d = 1.43E-011 F
// i.e The value of the distributed capacitance =
    14.3 pF
```

Scilab code Exa 6.6 To find percentage error

```
// To find percentage error
// Modern Electronic Instrumentation And Measurement
     Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 6-6 in Page 163


clear; clc; close;
```

```

// Given data
R = 10; //Resistance of the coil in ohm
f = 1*10^6; //The oscillator frequency in Hz
C = 65*10^-12; //The value of resonating capacitor in F
R_i = 0.02; //The value of the insertion resistor in ohm

//Calculations
w = 2*%pi*f;
Q_e = 1/(w*C*R);
printf("The effective Q of the coil = %0.1f\n",Q_e);
Q_i = 1/(w*C*(R+R_i));
printf("The indicated Q of the coil = %0.1f\n",Q_i);
%error = (Q_e - Q_i)/Q_e*100;
printf("The percentage error is = %0.1f %%",%error);

//Result
// The effective Q of the coil = 244.9
// The indicated Q of the coil = 244.4
// The percentage error is = 0.2 %
```

Scilab code Exa 6.7 To find percentage error

```
// To find percentage error
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 6-7 in Page 163

```

```

clear; clc; close;

// Given data
R = 0.1; //Resistance of the coil in ohm
f = 40*10^6; //The frequency at resonance in Hz
C = 135*10^-12; //The value of tuning capacitor in F
R_i = 0.02; //The value of the insertion resistor in ohm


//Calculations
w = 2*%pi*f;
Q_e = 1/(w*C*R);
printf("The effective Q of the coil = %d\n",ceil(Q_e));
Q_i = 1/(w*C*(R+R_i));
printf("The indicated Q of the coil = %d\n",ceil(Q_i));
%error = (Q_e - Q_i)/Q_e*100;
printf("The percentage error is = %d %%",ceil(%error));

//Result
// The effective Q of the coil = 295
// The indicated Q of the coil = 246
// The percentage error is = 17 %
```

Chapter 7

Oscilloscopes

Scilab code Exa 7.1 To find minimum distance

```
// To find minimum distance
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 7−1 in Page 184


clear; clc; close;

// Given data
D = 4*10^-2; //Deflection on the screen in m
G = 100*100; // Deflection factor in V/m
E_a = 2000; //Accelarating potential in V

//Calculations
// wkt. L = 2*d*E_a/(G*I_d)

//Also L/D = I_d / d
//Therefore
```

```

L = sqrt(2*D*E_a/G);
printf("The distance from the deflection plates to
   the oscilloscope tube screen = %0.3f m",L);

//Result
// The distance from the deflection plates to the
   oscilloscope tube screen = 0.126 m
```

Chapter 9

Signal Analysis

Scilab code Exa 9.1 To find dynamic range of spectrum analyser

```
// To find dynamic range of spectrum analyser
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 9-1 in Page 277


clear; clc; close;

// Given data
I_p = +25; //Third order intercept point in dBm
MDS = -85; //noise level in dBm

//Calculations

dynamic_range = 2/3*(I_p -MDS);
printf("The dynamic range of the spectrum analyser =
    %d dB",dynamic_range);

```

```
//Result
// The dynamic range of the spectrum analyser = 73
   dB
```

Scilab code Exa 9.2 To find minimum detectable signal

```
// To find minimum detectable signal
// Modern Electronic Instrumentation And Measurement
   Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 9-2 in Page 277


clear; clc; close;

// Given data
NF = 20; //Noise figure in dB
BW = 1*10^3; //Bandwidth in Hz

//Calculations
MDS = -114 +10* log10 ([BW/(1*10^6)]) +NF;
printf("The minimum detectable signal of the
   spectrum analyser = %d dBm",MDS);

//Result
// The minimum detectable signal of the spectrum
   analyser = -124 dBm
```

Scilab code Exa 9.3 To find dynamic range and total frequency display

```
// To find dynamic range and total frequency display
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick, William D. Cooper
// First Edition Second Impression, 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 9-3 in Page 285


clear; clc; close;

// Given data
T = 4; //Sample window in s
f_s = 20*10^3; // sample frequency in Hz
N = 10; //no of bits

//Calculations
f_r = 1/T;
f_h = f_s/2;
R_d = 20*log10(2^N);

printf("The ratio of the spectral calculation = %0.2f Hz\n",f_r);
printf("The maximum calculated spectral frequency = %d Hz\n",f_h);
printf("The dynamic range = %d dB",R_d);

//Result
// The ratio of the spectral calculation = 0.25 Hz
// The maximum calculated spectral frequency = 10000
```

```
     Hz
// The dynamic range = 60 dB
```

Chapter 11

Transducers as Input Elements to Instrumentation Systems

Scilab code Exa 11.1 To find change in resistance

```
// To find change in resistance
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt . Ltd . India
// Example 11−1 in Page 317


clear; clc; close;

// Given data
K =2; //Gauge factor
s = 1050; //stress in kg/cm^2
E = 2.1*10^6; //modulus of elasticity of steel in kg
   /cm^2

//Calculations
strain = s/E; //Hooke's law
```

```
change_in_resistance = K*strain;
%change = change_in_resistance * 100;

printf("The change in resistance = %0.3f\n",change_in_resistance);
printf("The percentage change in resistance = %0.1f %%",%change);

//Result
// The change in resistance = 0.001
// The percentage change in resistance = 0.1 %
```

Chapter 12

Analog and Digital Data Acquisition Systems

Scilab code Exa 12.1 To find percentage error

```
// To find percentage error
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 12-1 in Page 360


clear; clc; close;

// Given data
R = 1; //Resistance of the wire in ohm
R_L = 10*10^3; //Load resistance in ohm
I_supply = 50*10^-3; //power supply current in A
V_out = 1; //output of the amplifier in V

//Calculations
V_L = (V_out+(I_supply*R))*R_L/(2*R+R_L);
```

```
printf("The load voltage calculated = %0.2f\n",V_L);

%error = ceil((V_L -V_out)/V_L*100);
printf("The percentage error is about %d %%, which
   is unacceptable in most systems",%error);

//Result
// The load voltage calculated = 1.05
// The percentage error is about 5 %, which is
   unacceptable in most systems
```

Chapter 14

Fiber Optics Measurements

Scilab code Exa 14.1 To find acceptance angle and numerical aperture

```
// To find acceptance angle and numerical aperture
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 14-1 in Page 392


clear; clc; close;

// Given data
n_2 = 1.45; //Core index of refraction
n_1 = 1.47; //Cladding index of refraction

//Calculation
theta_c = acos(n_2/n_1);
theta_A = 2*asin(n_1*sin(theta_c));
NA = sqrt(n_1^2 -n_2^2);

printf("The critical angle of the fiber = %0.2f
```

```
degree\n",theta_c*180/%pi);
printf("The acceptance angle of the fiber = %0.2f degree\n",theta_A*180/%pi);
printf("The numerical aperture of the fiber = %0.3f",NA);

//Result
// The critical angle of the fiber = 9.46 degree
// The acceptance angle of the fiber = 27.97 degree
// The numerical aperture of the fiber = 0.242
```

Scilab code Exa 14.2 To find loss in the fiber

```
// To find loss in the fiber
// Modern Electronic Instrumentation And Measurement Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 14-2 in Page 393


clear; clc; close;

// Given data
NA_1 = 0.3; // numerical apertures of Source fiber
NA_2 = 0.242; //numerical apertures of receiving fiber

//Calculations
loss = 20*log10(NA_1/NA_2);
printf("The energy that is lost through the cladding of the receiving fiber = %0.2f dB",loss);
```

```
//Result
// The energy that is lost through the cladding of
   the receiving fiber = 1.87 dB
```

Scilab code Exa 14.3 To find current developed in photodiode

```
// To find current developed in photodiode
// Modern Electronic Instrumentation And Measurement
    Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 14-3 in Page 395


clear; clc; close;

// Given data
h = 6.63*10^-34; //Planck's constant
c = 3*10^8; //Speed of light in m/s
lambda = 1.3*10^-6; // photon wavelength in m
QE = 0.82; //Quantum efficiency
p = 75*10^-6; //Power in W
q = 1.6*10^-19; //Charge of an electron

//Calculations
e = h*c/lambda;
N = p/e;
N_QE= QE*N;
I = N_QE*q;
printf("The current developed in a PIN photodiode =
   %0.2e A",I);
```

```
//Result
// The current developed in a PIN photodiode = 6.43e
    -005 A
```

Scilab code Exa 14.4 To find elapsed time

```
// To find elapsed time
// Modern Electronic Instrumentation And Measurement
     Techniques
// By Albert D. Helfrick , William D. Cooper
// First Edition Second Impression , 2009
// Dorling Kindersly Pvt. Ltd. India
// Example 14-4 in Page 401


clear; clc; close;

// Given data
n = 1.55; //index of refraction
c = 3*10^8; //speed of light in m/s
d = 1.4*10^3; //Distance in m

//Calculations
v = c/n;
t = d/v;
printf("t = %0.1e s",t);
disp('Since twice the time to reach the break is
    required for the reflection to arrive at the
    reflectometer,' )
printf("Hence the total elapsed time = %0.3e s",2*t)
    ;

```

```
//Result
// t = 7.2e-006 s
// Since twice the time to reach the break is
   required for the reflection to arrive at the
   reflectometer,
// Hence the total elapsed time = 1.447e-005 s
```