# Scilab Textbook Companion for Surveying And Levelling by R. Subramanian[1]

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# Book Description

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

**Exa** Example (Solved example)

**Eqn** Equation (Particular equation of the above book)

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

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

# Contents

# List of Scilab Codes

# Chapter 1

# Introduction and Overview

**Scilab code Exa 1.5** Radius of curvature and Sensitivity of the bubble

```
//Example 1_5
clc;
clear;
close;

//Given data :
n=5;// number of divisions(no unit)
l=0.002;// length in m
D=80;// distance in m
s1=1.675;// reading of bubble at centre in m
s2=1.705;// reading of bubble shifted five divisions
    off-centre in m
s=s2-s1;// difference in reading in m
R=n*l*D/s;// radius of curvature in m
disp(R,"Radius of curvature in m");
S= 206265*s/(n*D);// sensitivity of bubble in s
disp(S,"Sensitivity of bubble in s");
// The answers vary due to round off error
```

**Scilab code Exa 1.6** Radius of bubble and Error in staff reading

```
//Example 1_6
clc;
clear;
close;

//Given data :
n=3;// number of divisions(no unit)
l=0.002;// length in m
D=50;// distance in m
S=40;// sensitivity in s
R=l*206265/S;// radius of curvature in m
e=n*l*D/R;// error in staff reading in m
disp(e,"error in staff reading in m");
```

**Scilab code Exa 1.7** Sensitivity of bubble

```
//Example 1_7
clc;
clear;
close;

//Given data :
l=0.002;// length in m
//Case 1
S=10;// sensitivity of bubble in s
R=l*206265/S;// radius of curvature in m
disp(R,"radius of curvature in m");
//Case 2
S=60;// sensitivity of bubble in s
R=l*206265/S;// radius of curvature in m
disp(R,"radius of curvature in m");
// The answers vary due to round off error
```

**Scilab code Exa 1.8** Sensitivity and Radius of the bubble

```
//Example 1_8
clc;
clear;
close;

//Given data :
D=50;// distance in m
//Case 1
r1=20;// bubble reading at left end in divisions
r2=10;// bubble reading at right end in divisions
s1=1.865;// staff reding in m
//Case 2
r3=10;// bubble reading at left end in divisions
r4=20;// bubble reading at right end in divisions
s2=1.785;// staff reding in m
sh1=(r1-r2)/2;// shift in divisions(Case 1)
sh2=(r4-r3)/2;// shift in divisions(Case 2)
sh=sh1+sh2;// total shift in divisions
s=s1-s2;// change in staff reading in m
n=sh;// number of divisions
l=0.002;// length in m
R=n*l*D/s;// radius of curvature of bubble in m
disp(R,"radius of curvature of bubble in m");
S=l*206265/R;// sensitivity of bubble in s
disp(S,"sensitivity of bubble in s");
// The answers vary due to round off error
```

# Chapter 2

# Measurement of Distance

**Scilab code Exa 2.1** True length of the line

```
//Example 2_1
clc;
clear;
close;

//Given data :
ml=273.35;// Measured length in m
al=29.93;// Actual length in m
dl=30;// Designated length  in m
tl=ml*(al/dl);// True length of the chain in m
disp(tl,"True length of the chain in m");
// The answers vary due to round off error
```

---

**Scilab code Exa 2.2** True length of the line

```
//Example 2_2
clc;
clear;
```

```
close;

//Given data :
tl=1276.54;// True length in m
ml=1274.84;// Measured length in m
dl=30;// Designated length in m
al=dl*(tl/ml);// Actual length in m
disp(al,"Actual length in m");
al1=(al-dl)*100;
disp(al1,"Excess length of chain in cm");
// The answers vary due to round off error
```

**Scilab code Exa 2.3** `True length of the line`

```
//Example 2_3
clc;
clear;
close;

//Given data :
al=(29.95+30.08)/2;// Actual length of chain in m
ml=590.48;// Measured length of chain in m
dl=30;// Designated length of chain in m
tl=ml*(al/dl);// True length of chain in m
disp(tl,"True length in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.4** `True length of the line`

```
//Example 2_4
clc;
clear;
close;
```

```

//Given data :
al=20.12;// Actual length of chain in m
mw=280;// Measured width in m
dl=20;// Designated width in m
tw=mw*(al/dl);// True width in m
ml=420;// Measured length  in m
tl=ml*(al/dl);// True length  in m
ta=tw*tl;// True area in sq.m
disp(ta,"True area in sq.m");
```

**Scilab code Exa 2.5** True length of the line

```
//Example 2_5
clc;
clear;
close;

//Given data :
// (a) For the first 1200 m:
ml1=1200;// Measured length in m
dl1=30;// Designated length in m
l1=dl1-0.2;// Length before measurement in m
L1=dl1+0.1;// Length after measuring 1200 m
al1=(l1+L1)/2;// Average length in m
tl1=ml1*(al1/dl1);// True length in m
disp(tl1,"True length for first portion in m")

// (b) For the next 1448 (i.e., 2648-1200) m:
ml2=1448;// Measured length in m
dl2=30;// Designated length in m
l2=dl2+0.1;// Length before measurement in m
L2=dl2+0.3;// Length after measuring 1200 m
al2=(l2+L2)/2;// Average length in m
tl2=ml2*(al2/dl2);// True length in m
```

```
disp(tl2,"True length for second portion in m")
TL=tl1+tl2;// True length of the line in m
disp(TL,"True length of the line in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.6** True volume of the embankment

```
//Example 2_6
clc;
clear;
close;

//Given data :
mv=486.95;// Measured volume in cubic m
al=20.1;// Actual length in m
dl=20;// Designated length in m
tv=mv*(al/dl)^3;// True volume in cubic m
disp(tv,"True volume in cubic m")
// The answers vary due to round off error
```

**Scilab code Exa 2.8** True area of the land

```
//Example 2_8
clc;
clear;
close;

//Given data :
ma=98.68;// Measured area in sq m
tl=15;// True length of line in m
ml=14.76;// Measured length of line in m
tap=ma*(tl/ml)^2;// True area of plan in sq m
disp(tap,"True area of plan in sq.m")
```

```
al=30.15;// Actual length of chain in m
ma=tap;// Measured area in sq m
dl=30;// Designated length in m
ta=ma*(al/dl)^2;// True area in sq m
tal=ta*25^2;// True area of land in sq m
disp(tal,"True area of land in sq m");
// The answers vary due to round off error
```

**Scilab code Exa 2.9** `Horizontal distance`

```
//Example 2_9
clc;
clear;
close;

//Given data :
ml=327.5;// Measured length in m

// (a) the slope of ground is 7.5 deg
hd=ml*cosd(7.5);// Horizontal distance in m
disp(hd,"(a)Horizontal distance in m");
// The answers vary due to round off error

// (b) the ground rises by 30 cm for every 10 m
   along the slope
hd=((10^2)+(0.3^2))^0.5;// Horizontal distance for
   10 m along the slope
Hd=ml*hd/10;// Horizontal distance for 327.5 m along
    the slope
disp(Hd,"(b)Horizontal distance for 327.5 m along
   the slope");
// The answers vary due to round off error

// (c) the gradient is 1:4
hd=((4^2)+(1^2))^0.5;// Horizontal distance along
```

```
    the slope
Hd=ml*4/hd;// Horizontal distance for 327.5 m along
    the slope
disp(Hd,"(c)Horizontal distance for 327.5 m along
    the slope");
// The answers vary due to round off error
```

**Scilab code Exa 2.10** Slope

```
//Example 2_10
clc;
clear;
close;

//Given data :
l=30;// Length of chain in m
// (a) Correction for slope is 0.06 m for 10 m
    length
// Therefore 10(1-cos a)=0.06
a=acosd(1-(0.06/10));// Slope in degree
disp(a,"(a)Slope in degree");
Ha=l*((secd(a))-1);// Hypotenusal allowance in m
disp(Ha,"  Hypotenusal allowance in m");
// The answers vary due to round off error

// (b) Correction for slope is 0.04 m for 10 m
    length
// Therefore 10(1-cos a)=0.04
a=acosd(1-(0.04/10));// Slope in degree
disp(a,"(b)Slope in degree");
Ha=l*((secd(a))-1);// Hypotenusal allowance in m
disp(Ha,"  Hypotenusal allowance in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.11** Maximum slope

```
//Example 2_11
clc;
clear;
close;

//Given data :
// (a) 1 in 1000
l=30;// Length in m
cf=1/1000;// Correction factor for (a)
// Therefore 30(1-cos a)=0.03
a=acosd(1-(cf/30));// Slope in degree
disp(a,"(a)The slope in degree should not be more
    than");
// The answers vary due to round off error

// (b) 1 in 500
cf=1/500;// Correction factor for (a)
// Therefore 30(1-cos a)=0.06
a=acosd(1-(cf/30));// Slope in degree
disp(a,"(a)The slope in degree should not be more
    than");
// The answers vary due to round off error
```

**Scilab code Exa 2.12** Horizontal distance

```
//Example 2_12
clc;
clear;
close;

```

```
//Given data :
// (a) AB:slope of 5.65 degree
ml=500.65;// Measured length in m
a=5.65;// Slope in degree
hd1=ml*cosd(a);// Horizontal distance AB in m
disp(hd1,"(a)Horizontal distance AB in m");
// The answers vary due to round off error

// (b) BC:gradient of 1:18
ml=700.35;// Measured length in m
hyp=((1^2)+(18^2))^0.5;// Hypotenuse length in m
hd2=ml*18/hyp;// Horizontal distance BC in m
disp(hd2,"(b)Horizontal distance BC in m");
// The answers vary due to round off error

// (c) falling slope of 2.56 m in 20 m
ml=400;// Measured length in m
a=asind(2.56/20);// Slope in degree
hd3=400*cosd(a);// Horizontal distance CD in m
disp(hd3,"(c)Horizontal distance CD in m");
// The answers vary due to round off error

Thd=hd1+hd2+hd3;// Total horizontal distance in m
disp(Thd,"Total horizontal distance in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.13** `Correct length of line`

```
//Example 2_13
clc;
clear;
close;

//Given data :
l=368.64;// Length of line in m
```

```
alpha=12*10^-6;// Coefficient of thermal expansion in per degree celcius
T=42;// Temperature during measurement in degree celcius
T0=20;// Standardized temperature in degree celcius
TC=l*alpha*(T-T0);// Temperature Correction in m
disp(TC,"Temperature Correction in m");
// The answers vary due to round off error
CL=l+TC;// Corrected length of line in m
disp(CL,"Corrected length of line in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.14** `Horizontal distance`

```
//Example 2_14
clc;
clear;
close;

//Given data :
l=30;// Length of tape in m
wl=10;// Weight per unit length of tape in N
P=120;// Tension pull in N
CS=l*(wl^2)/(24*P^2);// Correction due to sag in m
disp(CS,"Correction due to sag in m");
// The answers vary due to round off error
hd=l-CS;// Horizontal distance between the supports in m
disp(hd,"Horizontal distance between the supports in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.15** `Horizontal distance`

```
//Example 2_15
clc;
clear;
close;

//Given data :
d=0.6;// Distance by which tape was out of alignment
    in m
l=30;// Length of tape in m
CA=(d^2)/(2*l);// Correction for wrong alignment in
    m
disp(CA,"Correction for wrong alignment in m");
CL=l-CA;// Corrected length along the slope in m
disp(CL,"Corrected length along the slope in m");

// This corrected distance measured along the slope
    of gradient 1:12
lg=((12^2)+(1^2))^0.5;// Length along the gradient
    in units
hd=CL*12/lg;// Horizontal distance along the
    gradient 1:12 in m
disp(hd,"Horizontal distance along the gradient 1:12
    in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.16** Correction per tape length

```
//Example 2_16
clc;
clear;
close;

//Given data :
l=30;// Length of tape in m
alpha=11.5*10^-6;// Coefficient of thermal expansion
```

```
in per degree celcius
T=45;// Temperature during measurement in degree
    celcius
T0=20;// Standardized temperature in degree celcius
TC=l*alpha*(T-T0);// Temperature Correction in m
disp(TC,"Temperature Correction in m");
P0=100;// Tension pull during measurement in N
P=150;// Tension pull at standardized temperature in
    N
EP=P-P0;// Effective Tension pull in N
A=4*10^-6;// Area of cross section of tape in sq m
E=200*10^9;// Youngs modulus in N/sq m
CP=EP*l/(A*E);// Correction due to pull in m
disp(CP,"Correction due to pull in m");
uw=78600;// Unit weight of tape material in N/cubic
    m
wl=l*A*uw;// Weight of tape in N
disp(wl,"Weight of tape in N");
CS=l*(wl^2)/(24*P^2);// Correction for sag in m
disp(CS,"Correction for sag in m");
TCL=TC+CP-CS;// Total Correction per tape length in
    m
disp(TCL,"Total Correction per tape length in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.19** Displacement of offset

```
//Example 2_19
clc;
clear;
close;

//Given data :
l=18;// Length of offset in m
alpha=6;// angular error in degree
```

```
// (a) 1 cm= 10 m
s=10;// Equivalent Scale in m
dp=l*sind(alpha)/s;// Displacement parallel on to
    the chain line in cm
disp(dp,"(a) Displacement parallel on to the chain
    line in cm");
dP=l*(1-cosd(alpha))/s;// Displacement perpendicular
     on to the chain line in cm
disp(dP,"    Displacement perpendicular on to the
    chain line in cm");

// (b) 1:1500
s=15;// Equivalent Scale in m
dp=l*sind(alpha)/s;// Displacement parallel on to
    the chain line in cm
disp(dp,"(b) Displacement parallel on to the chain
    line in cm");
dP=l*(1-cosd(alpha))/s;// Displacement perpendicular
     on to the chain line in cm
disp(dP,"    Displacement perpendicular on to the
    chain line in cm");
// The answers vary due to round off error
```

**Scilab code Exa 2.20** `Maximum length of offset`

```
//Example 2_20
clc;
clear;
close;

//Given data :
alpha=4;// angular error in degree
// (a) 1 cm = 10 m
// The plotting accuracy is taken as 0.025 cm
s=10;// Equivalent Scale in m
```

```
l=s*0.025/sind(4);// Maximum length of offset in m
disp(l,"(a) Maximum length of offset in m");
// The answer provided in the textbook is wrong

// (b) 1 cm = 30 m
s=30;// Equivalent Scale in m
l=s*0.025/sind(4);// Maximum length of offset in m
disp(l,"(b) Maximum length of offset in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.21** `Accuracy`

```
//Example 2_21
clc;
clear;
close;

//Given data :
alpha=3;// Angular error in degree
r=cscd(alpha);// Accuracy in linear measurement
disp(r,"Accuracy in linear measurement");
disp("The Accuracy in linear measurement can be
   taken as 1 in 19");
// The answers vary due to round off error
```

**Scilab code Exa 2.22** `Maximum length of offset`

```
//Example 2_22
clc;
clear;
close;

//Given data :
```

```
l=0.025;// Minimum length that can be plotted in paper in m
// (a)The linear accuracy is 1 in 30 and scale is 1 cm = 20 m
r=30;
s=20;
L=l*r*s/sqrt(2);// Maximum length of offset in m
disp(L,"(a) Maximum length of offset in m");

// (b)The linear accuracy is 1 in 50 and scale is 1 in 3000
r=50;
s=30;
L=l*r*s/sqrt(2);// Maximum length of offset in m
disp(L,"(b) Maximum length of offset in m");
// The answers vary due to round off error
```

---

**Scilab code Exa 2.23** Maximum permissible error

```
//Example 2_23
clc;
clear;
close;

//Given data :
l=20;// Length of offset in m
r=40;
d=l/r;// Displacement due to linear error
// The combined error is equal to (((20*sin(alpha))^2)+(o.5^2))on the ground
// The combined error is equal to (1/40)(((20*sin(alpha))^2)+(o.5^2))on the paper
//Combined error on paper should be is equal to 0.025, which is plotting accuracy
alpha=asind(((((r*0.025)^2)-(0.5^2))/(l^2))^0.5);//
```

```
    Maximum error in angular measurement in degree
d=int(alpha);// in degree
m=int((alpha-d)*60);// in minutes
disp(m,d,"Maximum error in angular measurement in
    degree and minutes respectively");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 2.24** Length of AB

```
//Example 2_24
clc;
clear;
close;

//Given data :
AD=320;// Length of line AD in m
DC=640;// Length of line DC in m
DB=348;// Length of line DB in m
AC=430;// Length of line AC in m
// AC^2=AD^2 + DC^2 - 2AD*DC*cos(alpha)
ca=((AD^2)+(DC^2)-(AC^2))/(2*AD*DC);// Value of cos(
    alpha)
// AB^2=AD^2 + DB^2 - 2AD*DB*cos(alpha)
AB=sqrt((AD^2)+(DB^2)-(2*AD*DB*ca));// Length of
    line AB in m
disp(AB," Length of line AB in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.25** Length of AB

```
//Example 2_25
clc;
clear;
```

```
close;

//Given data :
// Triangles DAC and BDC are similar
// AC/AD = AD/AB
AD=65;// Length of line AD in m
AC=22.5;// Length of line AC in m
AB=AD*AD/AC;// Length of line AB in m
disp(AB,"Length of line AB in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.26** `Length of AB`

```
//Example 2_26
clc;
clear;
close;

//Given data :
// Triangles ABD and DFE are similar
// AB/AD = DF/FE
AD=40;// Length of line AD in m
DF=40;// Length of line DF in m
CA=40;// Length of line CA in m
FE=75-CA;// Length of line FE in m
AB=AD*DF/FE;// Length of line AB in m
disp(AB,"Length of line AB in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.27** `Length of AB`

```
//Example 2_27
clc;
```

```
clear;
close;

//Given data :
AC=42;// Length of AC in m
alpha=30;// Angle in degree
CB=AC/cosd(alpha);// Length of CB in m
disp(CB,"Length of CB in m");
beta=60;// Angle in degree
CD=AC/cosd(beta);// Length of CD in m
disp(CD,"Length of CD in m");
AB=AC*tand(alpha);// Length of AB in m
disp(AB,"Length of AB in m");
// The answers vary due to round off error
```

**Scilab code Exa 2.28** Lengths

```
//Example 2_28
clc;
clear;
close;

//Given data :
// Triangles AED and CED are similar
// AE/DE = DE/EC
DE=32;// Length of DE in m
EC=40;// LEngth of EC in m
AE=DE^2/EC;// Length of AE in m
CA=EC+AE;// Length of CA in m
disp(CA,"Length of CA in m");
// The answer provided in the textbook is wrong

// Triangles BGF and CGF are similar
// BG/GF = GF/CG
GF=36;// Length of GF in m
```

```
CG=44;// LEngth of CG in m
BG=GF^2/CG;// Length of BG in m
CB=CG+BG;// Length of CB in m
disp(CB,"Length of CB in m");

// Triangles CAB and CHJ are similar
// CH/CA = CJ/CB=0.25
// Therefore HJ/AB=0.25
HJ=23.6;// Length of HJ in m
AB=HJ/0.25;// Length of AB in m
disp(AB,"Length of AB in m");
// The answers vary due to round off error
```

# Chapter 5

# Plane Table Sureying

**Scilab code Exa 5.1** Error in plotted position

```
//Example 5_1
clc;
clear;
close;

//Given data :
d=25;// Displacement of the plotted point in cm
// (a) 1 mm = 0.1 m
k=1/(0.1*1000);// Representative fraction
E=d*k;// Displacement of plotted point cm
disp(E,"(a) Displacement of plotted point in cm");
disp("This is significant error");

// (b) 1 mm = 1 m
k=1/(1*1000);// Representative fraction
E=d*k;// Displacement of plotted point cm
disp(E,"(b) Displacement of plotted point cm");
disp("This is limiting error");

// (c) 1 mm = 2 m
k=1/(2*1000);// Representative fraction
```

```
E=d*k;// Displacement of plotted point cm
disp(E,"(c) Displacement of plotted point cm");
disp("This is not significant error");
```

# Chapter 8

# Computation of Areas

**Scilab code Exa 8.4** Areas by mid ordinate rule

```
//Example 8_4
clc;
clear;
close;

//Given data :
n=10;// Number of sections
l1=5.4;// Length of offset measures at 5 m in m
l2=6.8;// Length of offset measures at 15 m in m
l3=8.4;// Length of offset measures at 25 m in m
l4=7.5;// Length of offset measures at 35 m in m
l5=7.2;// Length of offset measures at 45 m in m
// According to mid-ordinate rule
A=(l1+l2+l3+l4+l5)*n;// Area in sq m
disp(A,"Area in sq. m");
```

**Scilab code Exa 8.5** Area by average ordinate rule and trapezoidal rule and parabol

```
//Example 8_5
clc;
clear;
close;

//Given data :
n=10;// Number of sections
l=100;// Total length in m
l1=3.8;// Length of offset measures at 0 m in m
l2=5.1;// Length of offset measures at 10 m in m
l3=6.5;// Length of offset measures at 20 m in m
l4=6.8;// Length of offset measures at 30 m in m
l5=5.9;// Length of offset measures at 40 m in m
l6=5.9;// Length of offset measures at 50 m in m
l7=6.2;// Length of offset measures at 60 m in m
l8=7.0;// Length of offset measures at 70 m in m
l9=6.6;// Length of offset measures at 80 m in m
l10=5.8;// Length of offset measures at 90 m in m
l11=4.2;// Length of offset measures at 100 m in m

// (a) Average ordinate rule
N=n+1;// Number of ordinates
S=l1+l2+l3+l4+l5+l6+l7+l8+l9+l10+l11;// Sum of offsets in m
A=S/N*l;// Area in sq. m
disp(A,"(a) Area in sq. m");

// (b) Trapezoidal rule
i=10;// Offset interval in m
A=i*(((l1+l11)/2)+l2+l3+l4+l5+l6+l7+l8+l9+l10);// Area in sq. m
disp(A,"(b) Area in sq. m");

// (c) Parabolic rule
i=10;// Offset interval in m
A=(1/3*i)*(l1+l11+(4*(l2+l4+l6+l8+l10))+(2*(l3+l5+l7+l9)));// Area in sq. m
disp(A,"(c) Area in sq. m");
```

**Scilab code Exa 8.6** `Area by average ordinate rule and trapezoidal rule and simpson`

```
//Example 8_6
clc;
clear;
close;

//Given data :
n=8;// Number of sections
l=12;// Length of each section in m
l1=0;// Length of offset in m
l2=5.2;// Length of offset in m
l3=7.4;// Length of offset in m
l4=8.6;// Length of offset in m
l5=7.9;// Length of offset in m
l6=8.5;// Length of offset in m
l7=8.2;// Length of offset in m
l8=9.1;// Length of offset in m
l9=7.6;// Length of offset in m

// (a) Average ordinate rule
N=n+1;// Number of ordinates
S=l1+l2+l3+l4+l5+l6+l7+l8+l9;// Sum of ordinates in m
A=(S/N)*l*n;// Area in sq. m
disp(A,"(a) Area in sq. m");

// (b) Trapezoidal rule and Simpson's rule
A=l*(((l1+l9)/2)+l2+l3+l4+l5+l6+l7+l8);// Area in sq. m
disp(A,"(b) Trapezoidal rule - Area in sq. m");
A=(1/3*l)*(l1+l9+(4*(l2+l4+l6+l8))+(2*(l3+l5+l7)));// Area in sq. m
disp(A,"    Simpson rule - Area in sq. m");
```

**Scilab code Exa 8.7** `Area by trapezoidal rule and simpson rule and coordinates`

```
//Example 8_7
clc;
clear;
close;

//Given data :
L1=5;// Length of each section of first part in m
L2=10;// Length of each section of second part in m
l1=2.5;// Length of offset in m
l2=3.8;// Length of offset in m
l3=8.4;// Length of offset in m
l4=7.6;// Length of offset in m
l5=10.5;// Length of offset in m
l6=9.3;// Length of offset in m
l7=5.8;// Length of offset in m
l8=7.8;// Length of offset in m
l9=6.9;// Length of offset in m
l10=8.4;// Length of offset in m

// (a) Trapezoidal rule
A1=L1*(((l1+l6)/2)+l2+l3+l4+l5);// Area of first
    part in sq. m
A2=L2*(((l6+l10)/2)+l7+l8+l9);// Area of second part
     in sq. m
A=A1+A2;// Total area in sq. m
disp(A,"(a) Total area in sq. m");

// (b) Simpson's rule
A12=L1*(l1+l2)/2;// Area between first and second
    ordinates in sq. m
A26=(L1/3)*(l2+l6+(4*(l3+l5)+(2*l4)));// Area
    between second and six ordinates in sq. m
```

```
A610=(L2/3)*(l6+l10+(4*(l7+l9)+(2*l8)));// Area
    between second and six ordinates in sq. m
A=A12+A26+A610;// Total area in sq. m
disp(A,"(b) Total area in sq. m");

// (c) Coordinates method
x1=5,y0=11;
x2=10,y1=12;
x3=15,y2=13;
x4=20,y3=14;
x5=25,y4=15;
x6=35,y5=16;
x7=45,y6=17;
x8=55,y7=18;
x9=65,y8=19;
x10=65,y9=110;
X=(y0*x1)+(y1*x2)+(y2*x3)+(y3*x4)+(y4*x5)+(y5*x6)+(
    y6*x7)+(y7*x8)+(y8*x9)+(y9*x10);
Y=(x1*y9)+(x2*y3)+(x3*y4)+(x4*y5)+(x5*y6)+(x6*y7)+(
    x7*y8)+(x8*y9);
A=(1/2)*(X-Y);// Area in sq. m
disp(A,"(c) Area in sq. m");
```

**Scilab code Exa 8.8** Area between chain line and boundary and first and last offset

```
//Example 8_8
clc;
clear;
close;

//Given data :
l1=3.4;// Length of offset in m
l2=6.2;// Length of offset in m
l3=6.8;// Length of offset in m
l4=5.9;// Length of offset in m
```

```
l5=8.4;// Length of offset in m
l6=6.2;// Length of offset in m
l7=10.3;// Length of offset in m
l8=11.5// Length of offset in m
l9=9.8;// Length of offset in m
l10=8.5;// Length of offset in m
x1=0;// Chainage in m
x2=7;// Chainage in m
x3=12;// Chainage in m
x4=18;// Chainage in m
x5=25;// Chainage in m
x6=32;// Chainage in m
x7=42;// Chainage in m
x8=48;// Chainage in m
x9=55;// Chainage in m
x10=65;// Chainage in m
// Area of trapezium = (sum of adjacent ordinates/2)*distance between ordinates
A=((l1+l2)/2*(x2-x1))+((l2+l3)/2*(x3-x2))+((l3+l4)/2*(x4-x3))+((l4+l5)/2*(x5-x4))+((l5+l6)/2*(x6-x5))+((l6+l7)/2*(x7-x6))+((l7+l8)/2*(x8-x7))+((l8+l9)/2*(x9-x8))+((l9+l10)/2*(x10-x9));// Area in sq. m
disp(A,"Area in sq. m");
```

**Scilab code Exa 8.9** `Area of ground`

```
//Example 8_9
clc;
clear;
close;

//Given data :
IR=6.973;// Initial Reading in cm
FR=2.921;// Final Reading in cm
```

```
C=0;
N=1;
M=100;// in sq. cm
A=M*(FR-IR+(10*N)+C);// Area in sq. cm
// Scale is 1 cm = 100 m
// 1 sq. cm represents 100*100 sq. m of land area
s=100;// Scale in m
AG=A*s*s;// Area of ground in sq. m
AG=AG/10000;// Area of ground in hectares
disp(AG,"Area of ground in hectares");
```

**Scilab code Exa 8.10** `Area of land`

```
//Example 8_10
clc;
clear;
close;

//Given data :
IR=8.942;// Initial Reading in cm
FR=3.678;// Final Reading in cm
C=30;
N=-2;
M=100;// in sq. cm
A=M*(FR-IR+(10*N)+C);// Area in sq. cm
// Scale is 1 cm = 150 m
// 1 sq. cm represents 150*150 sq. m of land area
s=150;// Scale in m
AG=A*s*s;// Area of ground in sq. m
AG=AG/10000;// Area of ground in hectares
disp(AG,"Area of ground in hectares");
```

**Scilab code Exa 8.11** `Value of M and C and Area of the zero circle`

```
//Example 8_11
clc;
clear;
close;

//Given data :
l=15.76;// Length of the tracer in cm
pi=22/7;
d=2.02;// Diameter in cm
M=l*pi*d;// in sq. cm
disp(M,"Value of M in cm");

// Anchor point outside
IRo=2.192;// Initial Reading in cm
FRo=4.352;// Final Reading in cm
No=1;// N for outside point
Co=0;// C for outside point
Ao=M*(FRo-IRo+(10*No)+Co);// Area calculated for
    anchor point outside in sq. cm

// Anchor point inside
IRi=0.012;// Initial Reading in cm
FRi=9.884;// Final Reading in cm
//Area calculated for anchor point outside = Area
    calculated for anchor point inside
Ai=Ao;// Area for anchor point inside in sq. cm
Ni=-2;// N for inside point
Ci=(Ai/M)-FRi+IRi-(10*Ni);// C for inside point
disp(Ci,"Value of C");
A0=M*Ci;// Area of zero circle in sq. cm
disp(A0,"Area of zero circle in sq. cm");
//"The answers vary due to round off error"
```

**Scilab code Exa 8.12** `lengths of tracing arm and anchor arm`

```
//Example 8_12
clc;
clear;
close;

//Given data :
M=100;
C=30;
d=2;// diameter in cm
// M = l*pi*d
pi=22/7;
l=M/(pi*d);// Length in cm
A0=M*C;// Area of zero circle in sq. cm
disp(A0,"Area of zero circle in sq. cm");

a=2.93;// in cm
// (a) when wheel is beyond pivot
// pi*(l^2 + 2*a*l + r^2)=3000
r=sqrt((3000/pi)-(l^2)-(2*a*l))
disp(r,"(a) Length  in cm");

// (b) when wheel is between pivot and tracing point
// pi*(l^2 - 2*a*l + r^2)=3000
r=sqrt((3000/pi)-(l^2)+(2*a*l))
disp(r,"(b) Length in cm");
//"The answers vary due to round off error"
```

**Scilab code Exa 8.13** Position of line PQ

```
//Example 8_13
clc;
clear;
close;

//Given data :
```

```
b=170;// Length of DC in m
a=250;// Length of AB in m
// h = h1 + h2 = 150
h=150;// Height in m
A=(1/2)*(b+a)*h;// Area of trapezium in sq. m
disp(A,"Area of trapezium in sq. m");
// Ratio is 7:3
r1=7;
r2=3;
sr=r1+r2;// Sum of ratios
A1=A*r1/sr;// Area of ABQP in sq. m
disp(A1,"Area of ABQP in sq. m");
A2=A*r2/sr;// Area of PQCD in sq. m
disp(A2,"Area of PQCD in sq. m");
x=sqrt((((r1*b^2)+(r2*a^2)))/(r1+r2));// Length of
    PQ in m
disp(x,"Length of PQ in m");
h1=h*(a-x)/(a-b);// Height h1 in m
disp(h1,"Height h1 in m");
h2=h-h1;// Height h2 in m
disp(h2,"Height h2 in m");
```

# Chapter 9

# Measurement of Elevations

**Scilab code Exa 9.1** Determining the position of given contours

```
//Example 9_1
clc;
clear;
close;

//Given data :
A=100.2;// Point A
B=100.9;// Point B
C=100.4;// Point C
D=99.8;// Point D
p1=100.4;// Point of elevation 1 in m
p2=100.6;// Point of elevation 2 in m
p3=100.8;// Point of elevation 3 in m
p4=100.6;// Point of elevation 4 in m
p5=100.8;// Point of elevation 5 in m
s=15;// since 15 m square

// On the line AB
d=B-A;// Difference in elevation in m
D1=s*(p1-A)/d;// Distance from A of point 1 in m
disp(D1,"Distance from A of point 1 in m");
```

```
D2=s*(p2-A)/d;// Distance from A  of point 2 in m
disp(D2,"Distance from A  of point 2 in m");
D3=s*(p3-A)/d;// Distance from A of point 3 in m
disp(D3,"Distance from A of point 3 in m");

// On the line BC
d=B-C;// Difference in elevation in m
// 100.4 m is a point C only
if C==p1 then
    disp("100.4 m is a point C only");
else
    D6=s*(p1-C)/d;// Distance from A of point 1 in m
disp(D6,"Distance from A of point 1 in m");
end
D4=s*(p4-C)/d;// Distance from A  of point 2 in m
disp(D4,"Distance from A  of point 2 in m");
D5=s*(p5-C)/d;// Distance from A of point 3 in m
disp(D5,"Distance from A of point 3 in m");
// The answers vary due to round off error
```

---

**Scilab code Exa 9.2** Determining the position of given contours

```
//Example 9_2
clc;
clear;
close;

//Given data :
A=100.1;// Point A
B=100.6;// Point B
C=99.9;// Point C
D=100.6;// Point D
E=99.8;// Point E
F=100.4;// Point F
p1=100.3;// Point of elevation 1 in m
```

```
p2=100.5;// Point of elevation 2 in m
p3=100.2;// Point of elevation 3 in m
p4=100.4;// Point of elevation 4 in m
p5=100.2;// Point of elevation 5 in m
s=10;// since 10 m square

// On the line AB
d=B-A;// Difference in elevation in m
D1=s*(p1-A)/d;// Distance from A of point 1 in m
disp(D1,"Distance from A of point 1 in m");
D2=s*(p2-A)/d;// Distance from A  of point 2 in m
disp(D2,"Distance from A  of point 2 in m");

// On the line CD
d=D-C;// Difference in elevation in m
D3=s*(p3-C)/d;// Distance from C of point 3 in m
disp(D3,"Distance from C of point 3 in m");
D4=s*(p4-C)/d;// Distance from C of point 4 in m
disp(D4,"Distance from C of point 4 in m");

// On the line EF
d=F-E;// Difference in elevation in m
if F==p4 then
    disp("The 100.4 contour is a point F");
else
    D6=s*(p4-A)/d;// Distance from C of point 6 in m
disp(D6,"Distance from C of point 6 in m");
end
D5=s*(p5-E)/d;// Distance from C of point 5 in m
disp(D5,"Distance from C of point 5 in m");
// The answers vary due to round off error
```

# Chapter 10

# Computation of Volumes

**Scilab code Exa 10.1** Cross sectional area

```
//Example 10_1
clc;
clear;
close;

//Given data :
b=6;// Width of subgrade in m
h=1.85;// Height at centre in m
s=2;// Side slope
a=b+(2*h*s);// Top width in m
A=(a+b)*(h/2);//  Area of section in sq. m
disp(A,"Area of section in sq. m");
// The answers vary due to round off error
```

---

**Scilab code Exa 10.2** Area of section

```
//Example 10_2
clc;
```

```
clear;
close;

//Given data :
// Area = {s*((b/2)^2)+((b/2)^2)*((b*h)+(s*h^2))}/((
   r^2)-(s^2))
s=1.5;// Side slope
b=8;// Width in m
h=2.8;// Height in m
r=4;// transverse slope
A = (s*((b/2)^2)+((b/2)^2)*((b*h)+(s*h^2)))/((r^2)-(
   s^2));// Area in sq. m
disp(A,"Area in sq. m");
// The answers vary due to round off error
```

**Scilab code Exa 10.3** Area of section

```
//Example 10_3
clc;
clear;
close;

//Given data :
b=16;// Width in m
s=1;// Side slope
r=4;// Transverse slope
h=1;// Height at mid-section in m
h1=((b/2)-(h*r))/(r-s);// Height 1 in m
h2=((b/2)+(h*r))/(r-s);// Height 2 in m
w1=(b/2)+(h1*s);// Width 1 in m
w2=(b/2)+(h2*s);// Width 2 in m
// Area of the section = area of  triangle OAC +
   area of triangle OBD
// The bases of triangles OAC and OBC are AO and OB,
    the lengths of which can be determined from the
```

```
    principle of similarity of triangles
// 4/(4/3)=(8+x)/(8-x)
// On simplifying we get 16x = 64
x=64/16;// Distance by which O is shifted from
    centre in m
AO=8-x;// Length of AO in m
OB=8+x;// Length of OB in m
A=(1/2)*AO*h1*s;// Area in filling in sq. m
disp(A,"Area in filling in sq. m");
A=(1/2)*OB*h2*s;// Area in cutting in sq. m
disp(A,"Area in cutting in sq. m");
```

**Scilab code Exa 10.4** `Area of three level section`

```
//Example 10_4
clc;
clear;
close;

//Given data :
b=9.2;// Formation width in m
s=2;// Side slope
r1=8;// Transverse slope of higher half
r2=15;// Transverse slope of lower half
h=2.15;// Height at mid-section in m
h1=((h*r1)-(b/2))/(r1+s);// Height 1 in m
h2=((b/2)+(h*r2))/(r2-s);// Height 2 in m
w1=(b/2)+(h1*s);// Width 1 in m
w2=(b/2)+(h2*s);// Width 2 in m
A=((h1+h2)*b/4)+((w1+w2)*h/2);// Area in sq. m
disp(A,"Area in sq. m");
// The answers vary due to round off error
```

**Scilab code Exa 10.5** Area of multilevel section

```
//Example 10_5
clc;
clear;
close;

//Given data :
// Area of triange AFD
b=4;// Breath in m
h=5.6;// Height in m
A1=1/2*b*h;// Area of AFD in sq. m
// Area of trapezium AFEO
a=5.6;// Side 1 in m
b=7.8;// Side 2 in m
h=4;// Height in m
A2=1/2*(a+b)*h;// Area of AFEO in sq. m
// Area of trapezium OEDB
a=7.8;// Side 1 in m
b=8.2;// Side 2 in m
h=4;// Height in m
A3=1/2*(a+b)*h;// Area of AFEO in sq. m
// Area of triange BDG
b=4;// Breath in m
h=8.2;// Height in m
A4=1/2*b*h;// Area of AFD in sq. m
A=A1+A2+A3+A4;// Total Area in sq. m
disp(A,"Total Area in sq. m");
//The answer provided in the textbook is wrong
```

**Scilab code Exa 10.6** Volume of earth work

```
//Example 10_6
clc;
clear;
```

```
close;

//Given data :
h=2.4;// Central height in m
b=12;// Formation width in m
s=1.5;// side slope
l=200;// Length in m
A=h*(b+(s*h));// Area in sq. m
V=A*l;// Volume in cubic m
disp(V,"Volume in cubic m");
```

**Scilab code Exa 10.7** Volume by trapezoidal formula

```
//Example 10_7
clc;
clear;
close;

//Given data :
b=8.8;// Formation width in m
s=1.5;// side slope
i=20;// Interval in m
h1=1.8;// Height at centre at 0 m in m
h2=2.4;// Height at centre at 20 m in m
h3=3.0;// Height at centre at 40 m in m
h4=3.6;// Height at centre at 60 m in m
A1=h1*(b+(s*h1));// Area at 0 m in sq. m
A2=h2*(b+(s*h2));// Area at 20 m in sq. m
A3=h3*(b+(s*h3));// Area at 40 m in sq. m
A4=h4*(b+(s*h4));// Area at 60 m in sq. m
V=i*(((A1+A4)/2)+A2+A3);// Total volume in cubic m
disp(V,"Total volume in cubic m");
// The answers vary due to round off error
```

**Scilab code Exa 10.8** Volume of earth work

```
//Example 10_8
clc;
clear;
close;

//Given data :
b=7.5;// Formation width in m
s=2;// side slope
i=30;// Interval in m
h1=1.8;// Height at centre at 0 m in m
h2=2.175;// Height at centre at 30 m in m
h3=2.55;// Height at centre at 60 m in m
h4=2.925;// Height at centre at 90 m in m
h5=3;// Height at centre at 120 m in m
A1=h1*(b+(s*h1));// Area at 0 m in sq. m
A2=h2*(b+(s*h2));// Area at 30 m in sq. m
A3=h3*(b+(s*h3));// Area at 60 m in sq. m
A4=h4*(b+(s*h4));// Area at 90 m in sq. m
A5=h5*(b+(s*h5));// Area at 120 m in sq. m

// By prismoidal formula
V=(i/3)*(A1+A5+(4*(A2+A4))+(2*A3));// Total volume
    in cubic m
disp(V,"Total volume by prismoidal formula in cubic
    m");
// The answers vary due to round off error

// By trapezoidal formula
V=(i/2)*(A1+A5+(2*(A2+A3+A4)));// Total volume in
    cubic m
disp(V,"Total volume by trapezoidal formula in cubic
    m");
```

```
// The answer provided in the textbook is wrong
```

**Scilab code Exa 10.9** Volume of earth work

```
//Example 10_9
clc;
clear;
close;

//Given data :
l=120;// Length in m
s=2;// Side slope
r=20;// Transverse slope
b=5;// Formation width in m
h=2.2;// Central height in m
// Area=(s*((b/2)^2) + r^2*((b*h)+(s*h^2)))/((r^2)-(
    s^2))
a=s*((b/2)^2);
b=r^2*((b*h)+(s*h^2));
c=(r^2)-(s^2);
A=(a+b)/c;// Area in sq. m
V=A*l;// Volume of earthwork in cubic m
disp(V,"Volume of earthwork in cubic m");
// The answers vary due to round off error
```

**Scilab code Exa 10.10** Depth of cutting at each section and Volume of earth work

```
//Example 10_10
clc;
clear;
close;

//Given data :
```

```
b=6;// Formation width in m
s=2;// side slope
i=20;// Interval in m
g1=214.2,r1=212.66;
g2=214.8,r2=213.16;
g3=215.1,r3=213.66;
g4=216.1,r4=214.16;
g5=216.9,r5=214.66;
g6=217.4,r6=215.16;
g7=218.2,r7=215.66;
h1=g1-r1;
h2=g2-r2;
h3=g3-r3;
h4=g4-r4;
h5=g5-r5;
h6=g6-r6;
h7=g7-r7;
A1=h1*(b+(s*h1));// Area at 0 m in sq. m
A2=h2*(b+(s*h2));// Area at 20 m in sq. m
A3=h3*(b+(s*h3));// Area at 40 m in sq. m
A4=h4*(b+(s*h4));// Area at 60 m in sq. m
A5=h5*(b+(s*h5));// Area at 80 m in sq. m
A6=h6*(b+(s*h6));// Area at 100 m in sq. m
A7=h7*(b+(s*h7));// Area at 120 m in sq. m

// By trapezoidal formula
V=(i/2)*(A1+A7+(2*(A2+A3+A4+A5+A6)));// Total volume
    in cubic m
disp(V,"Total volume by trapezoidal formula in cubic
    m");

// By prismoidal formula
V=(i/3)*(A1+A7+(4*(A2+A4+A6))+(2*(A3+A5)));// Total
    volume in cubic m
disp(V,"Total volume by prismoidal formula in cubic
    m");
// The answers vary due to round off error
```

**Scilab code Exa 10.11** Volume of tank

```
//Example 10_11
clc;
clear;
close;

//Given data :
gl=125.96;// Ground level in m
rl=121.22;// Reduced level in m
d=gl-rl;// Depth of the tank in m
l=72;
b=48;
sl=2;// Side slope for length
sb=1.5;// Side slope for width

// By trapezoidal formula
L=l+4.4+(4.4*sl);// Length of the tank in m
B=b+4.4+(4.4*sb);// Width of the tank in m
A1=l*b;// Area A1 in sq. m
A2=L*B;// Area A2 in sq.m
V=(A1+A2)*4.4/2;// Volume by trapezoidal formula in
    cubic m
disp(V,"Volume by trapezoidal formula in cubic m");

// By prismoidal formula
L=l+2.2+(2.2*sl);// Length of the tank in m
B=b+2.2+(2.2*sb);// Width of the tank in m
A=L*B;// Area at mid-depth in sq. m
V=(2.2/3)*(A1+A2+(4*A));// Volume by prismoidal
    formula in cubic m
disp(V,"Volume by prismoidal formula in cubic m");
```

**Scilab code Exa 10.12** Volume of earth work

```
//Example 10_12
clc;
clear;
close;

//Given data :
b=10;// Formation width in m
s=2;// side slope
r=8;// Transverse slope
h1=2;// Central height at 0 chainage in m
h2=2.4;// Central height at 20 chainage in m
h3=3;// Central height at 60 chainage in m
a=r^2*s/((r^2)-(s^2));
b1=(h1+(b/(2*s)))^2;
b2=(h2+(b/(2*s)))^2;
b3=(h3+(b/(2*s)))^2;
c=b^2/(4*s);
A1=(a*b1)-c;// Area at chainage 0 in sq. m
A2=(a*b2)-c;// Area at chainage 0 in sq. m
A3=(a*b3)-c;// Area at chainage 0 in sq. m

// Volume by trapezoidal formula
i=20;// Interval in m
V=((i/2)*(A1+A2))+((i/2)*(A2+A3));// Volume by
    trapezoidal formula in cubic m
disp(V,"Volume by trapezoidal formula in cubic m");

// Volume by prismoidal formula
i=20;// Interval in m
V=(i/3)*(A1+A3+(4*A2));// Volume by prismoidal
    formula in cubic m
disp(V,"Volume by prismoidal formula in cubic m");
```

```
// The answers vary due to round off error
```

**Scilab code Exa 10.13** Volume of cutting

```
//Example 10_13
clc;
clear;
close;

//Given data :
i=30;// Interval in m
j=40;// slope 1 in 40
x=30/40;// change in reduced level at each chainage in m
g1=181.5;// Ground level at 0 chainage in m
r1=179;// Reduced level at 0 chainage in m
g2=181.8;// Ground level at 0 chainage in m
r2=r1-x;// Reduced level at 0 chainage in m
g3=182.4;// Ground level at 0 chainage in m
r3=r2-x;// Reduced level at 0 chainage in m
h1=g1-r1;// Depth of the cutting at 0 chainage in m
h2=g2-r2;// Depth of the cutting at 0 chainage in m
h3=g3-r3;// Depth of the cutting at 0 chainage in m
b=9;// Formation width in m
s=2;// side slope
r=6;// Transverse slope
// Area=(s*((b/2)^2) + r^2*((b*h)+(s*h^2)))/((r^2)-(s^2))
a=r^2*s/((r^2)-(s^2));
b1=(h1+(b/(2*s)))^2;
b2=(h2+(b/(2*s)))^2;
b3=(h3+(b/(2*s)))^2;
c=b^2/(4*s);
A1=(a*b1)-c;// Area at chainage 0 in sq. m
A2=(a*b2)-c;// Area at chainage 0 in sq. m
```

```
A3=(a*b3)-c;// Area at chainage 0 in sq. m

// Volume by trapezoidal formula
V=(i/2)*((A1+A3)+(2*(A2)));// Volume by trapezoidal
    formula in cubic m
disp(V,"Volume by trapezoidal formula in cubic m");

// Volume by prismoidal formula
V=(i/3)*(A1+A3+(4*A2));// Volume by prismoidal
    formula in cubic m
disp(V,"Volume by prismoidal formula in cubic m");

PC=(i*s/3)*((r^2)/((r^2)-(s^2)))*((h2-h1)^2+(h3-h2)
    ^2);// Prismoidal Correction in cubic m
disp(PC,"Prismoidal Correction in cubic m");
// The answers vary due to round off error
```

**Scilab code Exa 10.15** Curvature correction

```
//Example 10_15
clc;
clear;
close;

//Given data :
h=2;// Height along centre line in m
b=10;// Formation width in m
s=1.5;// Side slope
r=8;// Transverse slope
h1=((8*h)-(b/2))/9.5;// Height in m
h2=((b/2)+(8*h))/6.5;// Heght in m
w1=(h-h1)*8;// Width in m
w2=(h2-h)*8;// Width in m
A=((s*((b/2)^2))+((r^2)*b*h)+((r^2)*s*(h^2)))/((r^2)
    -(s^2));// Area od section in sq. m
```

```
E=w1*w2*(w1+w2)/(3*A*r);// Eccentricity of centroid
    in m
R=180;// Radius of the curve in m
a=30;
pi=22/7;
l=R*a*pi/R;// Length in m
CC=A*E*l/R;// Curvature Correction in cubic m
disp(CC,"Curvature Correction in cubic m");
// The answers vary due to round off error
```

**Scilab code Exa 10.16** Capacity of a reservoir

```
//Example 10_16
clc;
clear;
close;

//Given data :
c1=260;// Contour 1
c2=258;// Contour 2
i=c1-c2;// Interval between contour
// scale 1 in 4000 => 1 cm = 40 m
x=40^2;// This factor x is multiplied with areas
    measured by planimeter to get area in sq. m
A1=400*x;// Area of contour 260 in m
A2=367.5*x;// Area of contour 258 in m
A3=327.5*x;// Area of contour 256 in m
A4=310*x;// Area of contour 254 in m
A5=277.5*x;// Area of contour 252 in m
A6=243.75*x;// Area of contour 250 in m
A7=205*x;// Area of contour 248 in m
A8=177.5*x;// Area of contour 246 in m
A9=147.5*x;// Area of contour 244 in m
A10=115*x;// Area of contour 242 in m
A11=0*x;// Area of contour 240 in m
```

```
// Volume by trapezoidal formula
V=(i/2)*(A1+A11+(2*(A2+A3+A4+A5+A6+A7+A8+A9+A10)));
    // Volume by trapezoidal formula in cubic m
disp(V,"Volume by trapezoidal formula in cubic m");

// Volume by prismoidal formula
V=(i/3)*(A1+A11+(4*(A2+A4+A6+A8+A10))+(2*(A3+A5+A7+
    A9)));// Volume by prismoidal formula in cubic m
disp(V,"Volume by prismoidal formula in cubic m");
```

**Scilab code Exa 10.17** `Volume of excavation`

```
//Example 10_17
clc;
clear;
close;

//Given data :
p=121.38;// Reduced level at P in m
q=119.64;// Reduced level at Q in m
r=120.32;// Reduced level at R in m
s=121.68;// Reduced level at S in m
rl=118.17;// Reduced level of excavation in m
l1=3;// Length of PS in m
l2=7.5;// Length of QR in m
d=6;// Distance between PS and QR in m
A=(l1+l2)*d/2;// Area of excavation in sq. m
hp=p-rl;// Height at P in m
hq=q-rl;// Height at Q in m
hr=r-rl;// Height at R in m
hs=s-rl;// Height at S in m
ah=(hp+hq+hr+hs)/4;// Average height in m
V=A*ah;// Volume in cubic m
disp(V,"Volume in cubic m");
// The answers vary due to round off error
```

**Scilab code Exa 10.18** Volume of earth excavated

```
//Example 10_18
clc;
clear;
close;

//Given data :
A=2.8;// Depth at point A in m
B=3.2;// Depth at point B in m
C=2.6;// Depth at point C in m
D=2.6;// Depth at point D in m
E=3.1;// Depth at point E in m
F=2.4;// Depth at point F in m
G=2.4;// Depth at point G in m
H=2.9;// Depth at point H in m
I=2.2;// Depth at point I in m
h1=A+C+G+I;// A,C,G,I are used once
h2=B+D+F+H;// B,D,F,H are used twice
h3=0;// Nothing is used thrice
h4=E;// E is used four times
a=10;// side of square in m
A=a*a;// Area in sq. m
V=A*(h1+(2*h2)+(3*h3)+(4*h4))/4;// Volume of
    excavation in cubic m
disp(V,"Volume of excavation in cubic m");
```

**Scilab code Exa 10.19** Volume of excavation

```
//Example 10_19
clc;
```

```
clear;
close;

//Given data :
a=103.71;// Reduced level at A in m
b=103.85;// Reduced level at B in m
c=104.35;// Reduced level at C in m
d=104.95;// Reduced level at D in m
e=104.09;// Reduced level at E in m
f=104.05;// Reduced level at F in m
g=104.25;// Reduced level at G in m
h=104.65;// Reduced level at H in m
i=104.95;// Reduced level at I in m
j=104.29;// Reduced level at J in m
k=104.45;// Reduced level at K in m
l=104.95;// Reduced level at L in m
m=104.75;// Reduced level at M in m
n=105;// Reduced level at N in m
o=104.7;// Reduced level at O in m
p=105.05;// Reduced level at P in m
q=104.85;// Reduced level at Q in m
rl=101.85;// Reduced level of excavation in m
A=a-rl;// Depth at A in m
B=b-rl;// Depth at B in m
C=c-rl;// Depth at C in m
D=d-rl;// Depth at D in m
E=e-rl;// Depth at E in m
F=f-rl;// Depth at F in m
G=g-rl;// Depth at G in m
H=h-rl;// Depth at H in m
I=i-rl;// Depth at I in m
J=j-rl;// Depth at J in m
K=k-rl;// Depth at K in m
L=l-rl;// Depth at L in m
M=m-rl;// Depth at M in m
N=n-rl;// Depth at N in m
O=o-rl;// Depth at O in m
P=p-rl;// Depth at P in m
```

```
Q=q-rl;// Depth at Q in m
h1=A+E+J+N+Q+O;// A,E,J,N,Q,O are used once
h2=B+C+D+F+K+P;// B,C,D,F,K,P are used twice
h3=I+M;// I,M are used thrice
h4=G+H+L;// G,H,L is used four times
a=10;// side of square in m
A=a*a;// Area in sq. m
V=A*(h1+(2*h2)+(3*h3)+(4*h4))/4;// Volume of excavation in cubic m
disp(V,"Volume of excavation in cubic m");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 10.20** Volume of earth excavation

```
//Example 10_20
clc;
clear;
close;

//Given data :
a=30;// side of square in m
A=a*15/2;// Base area in sq. m
// Base area for each triangular prism is the same
h1=2.85;// Height at P in m
h2=2.45;// Height at Q in m
h3=3.15;// Height at R in m
h4=3.55;// Height at S in m
h5=2.95;// Height at T in m

// Prism PQT
H1=(h1+h2+h5)/3;// Average height in m
V1=H1*A;// Volume in cubic m

// Prism QTR
H2=(h2+h5+h3)/3;// Average height in m
```

```
V2=H2*A;// Volume in cubic m

// Prism STR
H3=(h4+h5+h3)/3;// Average height in m
V3=H3*A;// Volume in cubic m

// Prism PTS
H4=(h1+h5+h4)/3;// Average height in m
V4=H4*A;// Volume in cubic m

V=V1+V2+V3+V4;// Total volume of excavation in cubic
    m
disp(V,"Total volume of excavation in cubic m");
```

**Scilab code Exa 10.21** `Volume of excavation`

```
//Example 10_21
clc;
clear;
close;

//Given data :

// PQRS
l1=52;// Length in m
b1=24;// Width in m
A1=l1*b1;// Base area in sq. m
h1=2.5;// Height in m
h2=2.5;// Height in m
h3=5.8;// Height in m
h4=5.8;// Height in m
H1=(h1+h2+h3+h4)/4;// Average height in m
V1=H1*A1;// Volume in cubic m

// QUVR
```

```
l2=b1;// Length in m
b2=l2+(2*11.6);// Width in m
A2=(l2+b2)*11.6/2;// Base area in sq. m
h1=5.8;// Height in m
h2=5.8;// Height in m
h3=0;// Height in m
h4=0;// Height in m
H2=(h1+h2+h3+h4)/4;// Average height in m
V2=H2*A2;// Volume in cubic m

// TPSW
l3=b1;// Length in m
b3=l3+5+5;// Width in m
A3=(l3+b3)*5/2;// Base area in sq. m
h1=2.5;// Height in m
h2=2.5;// Height in m
h3=0;// Height in m
h4=0;// Height in m
H3=(h1+h2+h3+h4)/4;// Average height in m
V3=H3*A3;// Volume in cubic m

// TUQP
l4=l1+5+11.6;// Length in m
A4=(l4*(11.6+5)/2)-(((5^2)+(11.6^2))/2);// Base area
    in sq. m
h1=5.8;// Height in m
h2=11.6;// Height in m
h3=0;// Height in m
h4=0;// Height in m
H4=(h1+h2+h3+h4)/4;// Average height in m
V4=H4*A4;// Volume in cubic m

// WSRV
V5=V4;// Volume in cubic m
V=V1+V2+V3+V4+V5;// Total volume in cubic m
disp(V,"Total volume in cubic m");
// The answer provided in the textbook is wrong
```

# Chapter 12

# Permanent Adjustments of the Level and Theodolite

**Scilab code Exa 12.1** `Correct readings at A and B`

```
//Example 12_1
clc;
clear;
close;

//Given data :
d=100;// Distance between points A and B in m
A=2.340;// Reading at point A in m
B=1.795;// Reading at point B in m
e=A-B;// True difference in elevation in m
A1=1.985;// Reading at point A when held at C in m
B1=1.435;// Reading at point B when held at C in m
ec=A1-B1;// Apparent difference in elevation when
    held at C in m
A=1.435;// Reading at A in m
// Add the true difference with A to get reading B
B=A+e;// Reading at B in m
disp(A,"Reading at A in m");
disp(B,"Reading at B in m");
```

```
if B1<B then
    disp("The line of collimation is inclined upwnwards.");
else
    disp("The line of collimation is inclined downwards.");
end
l=20;// legnth in m
cc=0.005*l/d;// Correction for reading at the closer peg
cf=0.005*(l+d)/d;// Correction for reading at the farther peg
Cc=B1-cc;// Correct reading at closer peg in m
Cf=A1-cf;// Correct reading at farther peg in m
D=Cf-Cc;// Difference in elevation in m
disp(D,"Difference in elevation in m");
```

**Scilab code Exa 12.2** Correct reading at peg B

```
//Example 12_2
clc;
clear;
close;

//Given data :
A1=1.865;// Reading of A at midway between A and B in m
B1=1.925;// Reading of B at midway between A and B in m
A2=1.405;// Reading at A with level at A in m
B2=1.460;// Reading at B with level at A in m
te=B1-A1;// True difference in elevation in m
ta=B2-A2;// Apparent difference in elevation in m
A=A2;// Reading at A with level at A in m
// Add the true difference with A to get reading B
```

```
B=A+te;//Reading at B with level at A in m
disp(B,"Correct reading at B in m");
if B2<B then
    disp("The line of collimation is inclined
       downwards.");
else
    disp("The line of collimation is inclined
       upwards.");
end
```

**Scilab code Exa 12.3** Correct readings at P and Q

```
//Example 12_3
clc;
clear;
close;

//Given data :
d=80;// Distance between P and Q in m
P1=1.860;// Reading at P when instrument at P in m
Q1=2.660;// Reading at Q when instrument at P in m
P2=1.215;// Reading at P when instrument at Q in m
Q2=1.815;// Reading at Q when instrument at Q in m
de1=Q1-P1;// Difference in elevation when instrument
    at P in m
de2=Q2-P2;// Difference in elevation when instrument
    at Q in m
te=(de1+de2)/2;// True difference in elevation in m
P=P1;// Reading at P with instrument at P in m
// Add the true difference with P to get reading Q
Q=P+te;//Reading at Q with instrument at P in m
disp(Q,"Correct reading at Q in m");
if Q2<Q then
    disp("The line of collimation is inclined
       downwards.");
```

```
else
    disp("The line of collimation is inclined
        upwards.");
end
Q=Q2;// Reading at Q with instrument at Q in m
// Add the true difference with Q to get reading P
P=Q+te;//Reading at P with instrument at Q in m
D=Q1-P;// Difference in reading in m
alpha=atand(D/d);// Inclination of line of
    collimation in degree
m=alpha*60;// Inclination of line of collimation in
    degree
disp(m,"Inclination of line of collimation in
    minutes");
// The answers vary due to round off error
```

**Scilab code Exa 12.4** Correct readings at P and Q

```
//Example 12_4
clc;
clear;
close;

//Given data :
d=100;// Distance between points A and B in m
l=20;// legnth in m
P1=1.885;// Reading of P at midway between P and Q
    in m
Q1=2.435;// Reading of Q at midway between P and Q
    in m
P2=1.635;// Reading at P with level at R in m
Q2=2.085;// Reading at Q with level at R in m
te=Q1-P1;// True difference in elevation in m
ta=Q2-P2;// Apparent difference in elevation in m
P=P2;// Reading at A with level at A in m
```

```
// Add the true difference with P to get reading Q
Q=P+te;//Reading at B with level at A in m
disp(Q,"Correct reading at B in m");
if Q2<Q then
    disp("The line of collimation is inclined downwards.");
else
    disp("The line of collimation is inclined upwards.");
end
c=0.1;// Correction in 100 m in m
cp=c*l/d;// Correction to reading at P in m
cq=c*(l+d)/d;// Correction to reading at Q in m
Cp=P2+cp;// Correct reading at P
Cq=Q2+cq;// Correct reading at Q
D=Cq-Cp;// Difference in elevation in m
disp(D,"Difference in elevation in m");
alpha=atand(c/d);// Inclination of line of collimation in degree
m=alpha*60;// Inclination of line of collimation in minutes
disp(m,"Inclination of line of collimation in minutes");
// The answers vary due to round off error
```

**Scilab code Exa 12.5** Correct readings at A and B

```
//Example 12_5
clc;
clear;
close;

//Given data :
A1=2.615;// Reading of A at midway between A and B in m
```

```
B1=3.175;// Reading of B at midway between A and B in m
A2=1.905;// Reading at A with level at A in m
B2=2.340;// Reading at B with level at A in m
te=B1-A1;// True difference in elevation in m
ta=B2-A2;// Apparent difference in elevation in m
A=A2;// Reading at A with level at A in m
// Add the true difference with A to get reading B
B=A+te;//Reading at B with level at A in m
disp(B,"Correct reading at B in m");
if B2<B then
    disp("The line of collimation is inclined downwards.");
else
    disp("The line of collimation is inclined upwards.");
end
// Correct reading at A = A2 + 25*tan(alpha)
// Correct reading at B = B2 + 75*tan(alpha)
D=B2-A2;// Difference in correct reading in m
E=75-25;
// D= 0.435 + 50*tan(alpha)
// 0.435 + 25*tan(alpha)= True difference in elevation (te)
alpha=atand((te-D)/E);// Inclination of line of collimation in degree
m=alpha*60;// Inclination of line of collimation in minutes
disp(m,"Inclination of line of collimation in minutes");
// The answers vary due to round off error
Ca=A2+(25*tand(alpha));// Correct reading at A in m
disp(Ca,"Correct reading at A in m");
Cb=B2+(75*tand(alpha));// Correct reading at A in m
disp(Cb,"Correct reading at A in m");
// The answers vary due to round off error
```

# Chapter 14

# Tachometry

**Scilab code Exa 14.1** Distance PQ and elevation of point Q

```
//Example 14_1
clc;
clear;
close;

//Given data :
r1=1.980;// Reading 1 in m
r2=1.660;// Reading 2 in m
r3=1.340;// Reading 3 in m
s=r1-r3;
K=100;// Instrument constant
C=0.5;// Instrument constant
D=(K*s)+C;// Horizontal distance PQ in m
disp(D,"Horizontal distance PQ in m");
R1=1020.5;// Reading 1 from P to a staff held at BM
    elevation in m
R2=2.85;// Reading 2 from P to a staff held at BM
    elevation in m
E=R1+R2;// Elevation of line of sight in m
Eq=E-r2;// Elevation of point Q in m
disp(Eq,"Elevation of point Q in m");
```

**Scilab code Exa 14.2** `Stadia constants K and C`

```
//Example 14_2
clc;
clear;
close;

//Given data
q1=1.354;// Observed reading 1 at Q for instrument
    at P in m
q2=1.603;// Observed reading 2 at Q for instrument
    at P in m
q3=1.852;// Observed reading 3 at Q for instrument
    at P in m
r1=1.152;// Observed reading 1 at R for instrument
    at P in m
r2=1.65;// Observed reading 2 at R for instrument at
     P in m
r3=2.149;// Observed reading 3 at R for instrument
    at P in m
D1=50;// Distance at Q for instrument at P in m
D2=100;// Distance at R for instrument at P in m
// D=(K*s)+C      - eq 1
// For observation from P to Q
s1=q3-q1;// Difference between staff reading q3 and
    q1 in m
// For observation from P to R
s2=r3-r1;// Difference between staff reading p3 and
    p1 in m
// substituting values in eq 1
// D1=(K*s1)+C
// D2=(k*s2)+C
// Solving the equations by eliminating C, then
    equating K
```

```
K=(D2-D1)/(s2-s1);// Stadia contsant K
disp(K,"Stadia contsant K")
C=D2-(K*s2);// Stadia constant C
disp(C,"Stadia contsant C")
// The answers vary due to round off error
```

**Scilab code Exa 14.3** `Stadia interval`

```
//Example 14_3
clc;
clear;
close;

//Given data
f=0.25;// Focal length of objective lens in m
d=0.15;// Distance from the objective lens to the
    vertical axis in m
C=f+d;// Constant C
r1=1.460;// Reading 1 in m
r2=2.055;// reading 2 in m
s=r2-r1;// Staff intercept in m
D=60;// Distance in m
K=(D-C)/s;// Constant K
// K=f/i, where i is stadia interval in m
i=f/K*1000;// Stadia interval in mm
disp(i,"Stadia interval in mm");
// The answers vary due to round off error
```

**Scilab code Exa 14.4** `Reduced level of Q`

```
//Example 14_4
clc;
clear;
```

```
close;

//Given data
r1=1.905;// Reading 1 in m
r2=2.480;// Reading 2 in m
r3=3.055;// Reading 3 in m
s=r3-r1;// Intercept in m
// As the staff is held normal to the  line of sight
K=100;// Instrument constant
C=0.5;// Instrument constant
L=(K*s)+C;// Inclined length in m
d=6;// Degree
m=36;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle in degree
D=L*cosd(teta);// Horizontal distance in m
disp(D,"Horizontal distance in m");
V=L*sind(teta);// Difference in height from the
    instrument height at P in m
disp(V,"Difference in height from the instrument
    height at P in m");
RL1=852.55;// RL of BM in m
a=1.855;// Reading from P with the line of sight
    horizontal to a BM of RL 852.55 in m
RL=RL1+a;// RL of line of sight in m
RL2=RL+V-r2;// RL of Q in m
disp(RL2,"RL of Q in m");
// The answers vary due to round off error
```

**Scilab code Exa 14.5** Distance QR and gradient and RLs of Q and R

```
//Example 14_5
clc;
clear;
close;

//Given data
K=100;// Instrument constant
C=0.3;// Instrument constant

// Observation to Q
disp("(a) Observation to Q");
q1=2.105;// Reading 1 at Q in m
q2=2.470;// Reading 2 at Q in m
q3=2.835;// Reading 3 at Q in m
s1=q3-q1;// Intercept in m
d=5;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle in degree
L=(K*s1*cosd(teta))+C;// Inclined length in m
D1=L*cosd(teta);// Horizontal distance in m
disp(D1,"Horizontal distance in m");
V1=L*sind(teta);// Difference in height from the instrument height at P in m
disp(V1,"Difference in height in m");

// Observation to R
disp("(b) Observation to R");
r1=2.215;// Reading 1 at R in m
r2=2.560;// Reading 2 at R in m
r3=2.905;// Reading 3 at R in m
s2=r3-r1;// Intercept in m
d=1;// Degree
```

```
m=08;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle in degree
L=(K*s2*cosd(teta))+C;// Inclined length in m
D2=L*cosd(teta);// Horizontal distance in m
disp(D2,"Horizontal distance in m");
V2=L*sind(teta);// Difference in height from the instrument height at P in m
disp(V2,"Difference in height in m");

PQ=D1;// Length in m
PR=D2;// Length in m
d=58;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle QPR in degree
QR=sqrt((PQ^2)+(PR^2)-(2*PQ*PR*cosd(teta)));// Length in m
RL1=285.35;// RL of BM in m
a=2.255;// Reading from P with the line of sight horizontal to a BM of RL 285.35 in m
RL=RL1+a;// RL of line of sight in m
RL2=RL+V1-q2;// RL of Q in m
disp(RL2,"RL of Q in m");
RL3=RL+V2-r2;// RL of R in m
disp(RL3,"RL of R in m");
d=RL2-RL3;// Difference in elevation of Q and R in m
disp(d,"Difference in elevation of Q and R in m");
```

```
G=d/QR;// Gradient from Q t R
disp(G,"Gradient from Q t R");
// The answers vary due to round off error
```

**Scilab code Exa 14.6** `RL of P`

```
//Example 14_6
clc;
clear;
close;

//Given data
K=100;// Instrument constant
C=0.3;// Instrument constant

// Observation from A to P
disp("(a) Observation from A to P");
a1=2.235;// Reading 1 at P in m
a2=2.795// Reading 2 at P in m
a3=3.355;// Reading 3 at P in m
s1=a3-a1;// Intercept in m
d=3;// Degree
m=45;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle in degree
L=(K*s1*cosd(teta))+C;// Inclined length in m
D1=L*cosd(teta);// Horizontal distance in m
disp(D1,"Horizontal distance in m");
V1=L*sind(teta);// Difference in height from the
    instrument height at P in m
```

```
disp(V1,"Difference in height in m");
RL1=235.455;// RL of BM in m
a=1.75;// Reading at BM in m
RL=RL1+a;// RL of line of sight in m
RL2=RL+V1-a2;// RL of P in m
disp(RL2,"RL of P in m");
x=RL2;

// Observation from B to P
disp("(b) Observation from B to P");
b1=0.945;// Reading 1 at P in m
b2=1.490// Reading 2 at P in m
b3=2.035;// Reading 3 at P in m
s2=b3-b1;// Intercept in m
d=2;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle in degree
L=((K+s2)*cosd(teta))+C;// Inclined length in m
D2=L*cosd(teta);// Horizontal distance in m
disp(D2,"Horizontal distance in m");
V2=(1/2)*((K+s2)*sind(2*teta))+(C*sind(teta));//
    Difference in height from the instrument height
    at P in m
disp(V2,"Difference in height in m");
RL1=235.455;// RL of BM in m
a=2.25;// Reading at BM in m
RL=RL1+a;// RL of line of sight in m
RL2=RL+V2-b2;// RL of P in m
disp(RL2,"RL of P in m");
y=RL2;
RL=(x+y)/2;// Average RL of P in m
disp(RL,"Average RL of P in m");
```

```
// The answers vary due to round off error
```

**Scilab code Exa 14.7** `Gradient P to Q`

```
//Example 14_7
clc;
clear;
close;

//Given data
K=100;// Instrument constant
C=0.3;// Instrument constant

// (a) Observation to P
disp("(a) Observation from A to P");
p1=1.35;// Reading 1 at P in m
p2=2.10;// Reading 2 at P in m
p3=2.85;// Reading 3 at P in m
s1=p3-p1;// Intercept in m
d=84;// Degree
m=36;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta1=d+(m*1/60)+(s*1/3600);// Bearing angle in degree
d=3;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
```

```
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta2=d+(m*1/60)+(s*1/3600);// Vertical angle in
    degree
L=(K*s1)+C;// Inclined length in m
D1=L*cosd(teta2);// Horizontal distance in m
disp(D1,"Horizontal distance in m");
V1=L*sind(teta2);// Difference in height from the
    instrument height at P in m
disp(V1,"Difference in height in m");

// (b) Observation to Q
disp("(b) Observation from A to Q");
q1=1.955;// Reading 1 at Q in m
q2=2.875;// Reading 2 at Q in m
q3=3.765;// Reading 3 at Q in m
s2=q3-q1;// Intercept in m
d=142;// Degree
m=24;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta3=d+(m*1/60)+(s*1/3600);// Bearing angle in
    degree
d=2;// Degree
m=45;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta4=d+(m*1/60)+(s*1/3600);// Vertical angle in
    degree
L=(K*s2)+C;// Inclined length in m
```

```
D2=L*cosd(teta4);// Horizontal distance in m
disp(D2,"Horizontal distance in m");
V2=L*sind(teta4);// Difference in height from the
    instrument height at P in m
disp(V2,"Difference in height in m");
teta5=teta3-teta1;// Angle PAQ in degree
// Using cosine rule
AP=D1;
AQ=D2;
PQ=sqrt((AP^2)+(AQ^2)-(2*AP*AQ*cosd(teta5)));//
    Length of PQ in m
// Assuming the horizontal line of sight at A as
    datum
EP=V1-p2;// Elevation of P in m
EQ=V2-q2;// Elevation of Q in m
DE=EP-EQ;// Difference in elevation in m
disp(DE,"Difference in elevation in m");
Gr=DE/PQ;// Gradient from P to Q
disp(Gr,"Gradient from P to Q");
// The answers vary due to round off error
// The answer provided in the textbook is wrong
```

**Scilab code Exa 14.9** Tachometric constants K and C

```
//Example 14_9
clc;
clear;
close;

//Given data
p1=1.135;// Observed reading 1 at P for instrument
    at O in m
p2=1.284;// Observed reading 2 at P for instrument
    at O in m
p3=1.433;// Observed reading 3 at P for instrument
```

```
at O in m
q1=1.025;// Observed reading 1 at Q for instrument at O in m
q2=1.325;// Observed reading 2 at Q for instrument at O in m
q3=1.624;// Observed reading 3 at Q for instrument at O in m
D1=30;// Distance at P for instrument at O in m
D2=60;// Distance at Q for instrument at O in m
// D=(K*s)+C     - eq 1
// For observation from O to P
s1=p3-p1;// Difference between staff reading q3 and q1 in m
// For observation from O to Q
s2=q3-q1;// Difference between staff reading p3 and p1 in m
// substituting values in eq 1
// D1=(K*s1)+C
// D2=(k*s2)+C
// Solving the equations by eliminating C, then equating K
K=(D2-D1)/(s2-s1);// Stadia contsant K
disp(K,"Stadia contsant K");
C=D2-(K*s2);// Stadia constant C
disp(C,"Stadia contsant C");
// The answers vary due to round off error
```

**Scilab code Exa 14.10** `Tachometric constants K and C`

```
//Example 14_10
clc;
clear;
close;

//Given data
```

```
a1=1.325;// Observed reading 1 at A for instrument
    at P in m
a2=2.122;// Observed reading 2 at A for instrument
    at P in m
b1=0.985;// Observed reading 1 at B for instrument
    at P in m
b2=2.382;// Observed reading 2 at B for instrument
    at P in m
D1=80;// Distance at A for instrument at P in m
D2=140;// Distance at B for instrument at P in m
d=2;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta1=d+(m*1/60)+(s*1/3600);// Vertical angle in
    degree
d=1;// Degree
m=36;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta2=d+(m*1/60)+(s*1/3600);// Vertical angle in
    degree
// D=((K*s*cos(teta))+C)*cos(teta)    - eq 1
// For observation from P to A
s1=(a2-a1)*(cosd(teta1)^2);// Difference between
    staff reading q3 and q1 in m
// For observation from P to B
s2=(b2-b1)*(cosd(teta2)^2);// Difference between
    staff reading p3 and p1 in m
// substituting values in eq 1
```

```
// D1=((K*s1*cos(teta1))+C)*cos(teta1)
// D2=((K*s2*cos(teta2))+C)*cos(teta2)
// Solving the equations by eliminating C, then
   equating K
K=(D2-D1)/(s2-s1);// Stadia contsant K
disp(K,"Stadia contsant K")
x=cosd(teta2);
C=x*(D2-(K*s2));// Stadia constant C
disp(C,"Stadia contsant C")
// The answers vary due to round off error
```

**Scilab code Exa 14.11** `Distance between P and Q`

```
//Example 14_11
clc;
clear;
close;

//Given data
K=1000;// Stadia constant K
C=0.4;// Stadia constant C
n=21.35;// Number of revolutions of micrometer screw
s1=3;// Intercept in m
d=8;// Degree
m=15;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// Vertical angle in
   degree
D=((K*s1*(cosd(teta)^2))/n)+(C*cosd(teta));//
   Horizontal Distance in m
```

```
disp(D,"Horizontal Distance in m");
// The answers vary due to round off error
```

**Scilab code Exa 14.12** Number of turns of the micrometer screw

```
//Example 14_12
clc;
clear;
close;

//Given data
K=1000;// Stadia constant K
C=0.5;// Stadia constant C
s1=5;// Intercept in m
d=6;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// Vertical angle in degree
D=258;// Horizontal distance between A and B in m
n=(K*s1*(cosd(teta)^2))/(D-(C*cosd(teta)));// Number of revolutions of micrometer screw
disp(n,"Number of revolutions of micrometer screw")
// The answers vary due to round off error
```

**Scilab code Exa 14.13** Finding constant K

```
//Example 14_13
```

```
clc;
clear;
close;

//Given data
K=100;// Stadia constant K
C=0.5;// Stadia constant C
p1=1.335;// Reading 1 at P in m
p2=2.335;// Reading 2 at P in m
p3=3.335;// Reading 3 at P in m
s1=p3-p1;// Intercept in m
d=5;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// Vertical angle in
    degree
D=(K*s1*(cosd(teta)^2))+(C*cosd(teta));// Horizontal
     Distance in m
disp(D,"Horizontal Distance in m");
V=(1/2)*(K*s1*sind(2*teta))+(C*sind(teta));//
    Difference in height in m
disp(V,"Difference in height in m");
PQ=D;
RL1=1030.5;// RL of BM in m
a=2.355;// Reading at BM in m
RL=RL1+a;// RL of line of sight in m
RL2=RL+V-p2;// RL of Q in m
disp(RL2,"RL of P in m");
s2=3;// Intercept in m
n=14.93;// Number of revolutions of micrometer screw
// D=((K*s1*(cosd(teta)^2))/n)+(C*cosd(teta))
K=(D-(C*cosd(teta)))/(s2*(cosd(teta)^2)/n);// Stadia
     constant K
```

```
disp(K,"Stadia constant K");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 14.14** Constants K and C of the instrument

```
//Example 14_14
clc;
clear;
close;

//Given data
s=1.5;// Intercept in m
D1=60;// Distance from O in m
D2=120;// Distance from O in m
n1=22.5;// Number of revolutions of micrometer screw for 60 m
n2=11.28;// Number of revolutions of micrometer screw for 120 m
// D=(K*s/n)+C     - eq 1
// Substituting the values in eq 1
// D1=(K*s1/n1)+C
// D2=(k*s2/n2)+C
// Solving the equations by eliminating C, then equating K
K=(D2-D1)/((s/n2)-(s/n1));// Stadia contsant K
disp(K,"Stadia contsant K");
C=-(D2-(K*s/n2));// Stadia constant C
disp(C,"Stadia contsant C");
// The answers vary due to round off error
```

**Scilab code Exa 14.15** Distance from the objective lens

```
//Example 14_15
```

```
clc;
clear;
close;

//Given data
f0=11.6;// Focal length of anallactic lens in cm
f=25;// Focal length of objective lens in cm
d=13.5;// Distance from objective lens to vertical axis in cm
K=100;// Multiplying constant
N=f0+(f*d/(f+d));// Distance between anallactic lens and objective lens in cm
disp(N,"Distance between anallactic lens and objective lens in cm");
// K=(f*f0)/((f+f0-N)*i)
i=(f*f0)/(K*(f+f0-N));// Stadia interval in cm
disp(i,"Stadia interval in cm");
// The answers vary due to round off error
```

**Scilab code Exa 14.16** Focal length and Distance at which lens is placed

```
//Example 14_16
clc;
clear;
close;

//Given data
f=24;// Focal length of objective lens in cm
d=10.5;// Distance from objective lens to vertical axis in cm
K=100;// Multiplying constant
i=0.17;// Stadia interval in cm
// N=f0+(f*d/(f+d))
// f0=N-(f*d/(f+d))
// Let a=(f*d/(f+d)), then
```

```
a=(f*d/(f+d));
// f0=N-a => f0=N-7.3
// N=f0+7.3
// K=(f*f0)/((f+f0-N)*i)
// K=(f*f0)/((f+f0-f0 -7.3)*i)
// Therefore
f0=K*(f-a)*i/f;// Focal length of anallactic lens in
    cm
disp(f0,"Focal length of anallactic lens in cm");
N=f0+a;// Distance between anallactic lens and
    objective lens in cm
disp(N,"Distance between anallactic lens and
    objective lens in cm");
// The answers vary due to round off error
```

**Scilab code Exa 14.17** `Horizontal distance PQ and RL of Q`

```
//Example 14_17
clc;
clear;
close;

//Given data
r1=1;
r2=4;
s1=r2-r1;// Intercept in m
d=3;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta1=d+(m*1/60)+(s*1/3600);// Vertical angle in
```

```
degree
d=6;// Degree
m=15;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta2=d+(m*1/60)+(s*1/3600);// Vertical angle in degree
D=s1/(tand(teta2)-tand(teta1));// Horizontal distance PQ in m
disp(D,"Horizontal distance PQ in m");
V=D*tand(teta1);// Difference in height in m
RL1=985.55;// RL of BM in m
a=2.345;// Reading at BM in m
RL=RL1+a;// RL of line of sight in m
RL2=RL+V-r1;// RL of P in m
disp(RL2,"RL of P in m");
// The answers vary due to round off error
```

**Scilab code Exa 14.18** `Horizontal distance AB and RL of B`

```
//Example 14_18
clc;
clear;
close;

//Given data
r1=1;
r2=5;
s1=r2-r1;// Intercept in m
d=2;// Degree
m=30;// Minutes
```

```
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta1=d+(m*1/60)+(s*1/3600);// Vertical angle in
    degree
d=3;// Degree
m=45;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta2=d+(m*1/60)+(s*1/3600);// Vertical angle in
    degree
D=s1/(tand(teta1)+tand(teta2));// Horizontal
    distance PQ in m
disp(D,"Horizontal distance PQ in m");
V=D*tand(teta1);// Difference in height in m
RL1=258.5;// RL of BM in m
a=1.875;// Reading at BM in m
RL=RL1+a;// RL of line of sight in m
RL2=RL-V-r1;// RL of P in m
disp(RL2,"RL of P in m");
// The answers vary due to round off error
```

**Scilab code Exa 14.19** Percentage error in horizontal distance

```
//Example 14_19
clc;
clear;
close;
```

```

//Given data
r1=1.235;// Reading 1 at P in m
r2=2.2// Reading 2 at P in m
r3=3.165;// Reading 3 at P in m
s1=r3-r1;// Intercept in m
D=100*s1;// Horizontal distance in m
d=3;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle in degree
I=s1*cosd(teta);// Intercept normal to the line of
    sight in m
CD=100*I;// Correct distance in m
e=D-CD;// Error in m
ep=e*100/D;// Error percentage
disp(ep,"Error percentage");
// The answers vary due to round off error
```

**Scilab code Exa 14.20** Error in horizontal distance

```
//Example 14_20
clc;
clear;
close;

//Given data
l=4;// Length of staff in m
x=0.12;// length out of plumb in m
alpha=atand(x/l);// angle in degree
```

```
r1=2.385;// Reading 1 in m
r2=1.063;// Reading 2 in m
s1=r1-r2;// Staff intercept in m
d=8;// Degree
m=30;// Minutes
// 1 degree = 60 minutes.
// Therefore 1 minute = 1/60 degree
s=0;// Seconds
// 1 minute = 60 seconds
// 1 degree = 3600 seconds.
// Therefore 1 second = 1/3600 degree
teta=d+(m*1/60)+(s*1/3600);// angle in degree
Cs=s1*cosd(teta+alpha)/cosd(teta);// Correct value
    of intercept in m
CD=100*Cs*(cosd(teta)^2);// Correct horizontal
    distance in m
E=100*(cosd(teta)^2)*(s1-Cs);// Error in disatnce in
     m
disp(E,"Error in disatnce in m");
// The answers vary due to round off error
```

# Chapter 15

# Curve Surveying

**Scilab code Exa 15.1** Radius of curve

```
//Example 15_1
clc;
clear;
close;

//Given data
d=3*3.14/180;// Degree of curve in radian
a=30;// Length of arc in m
R=a/d;// Radius of the curve in m
disp(R,"Radius of the curve in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.2** Degree designation of the curve

```
//Example 15_2
clc;
clear;
close;
```

```
//Given data
a=20;// Length of arc in m
R=380;// Radius of the curve in m
d=a/R;// Degree of curve in radian
d=d*180/3.14;// Degree of curve in degree
D=d;// Degree destination of the curve in degree
disp(D,"Degree destination of the curve in degree");
// The answers vary due to round off error
```

**Scilab code Exa 15.3** Tangent distance and length of long chord and length of arc a

```
//Example 15_3
clc;
clear;
close;

//Given data
a=30;// Length of arc in m
d=4*3.14/180;// Degree of curve in radian
R=a/d;// Radius of the curve in m
teta=36;// Deflection angle in degree
TD=R*tand(teta/2);// Tangent distance in m
disp(TD,"Tangent distance in m");
l=2*R*sind(teta/2);// Length of long chord in m
disp(l,"Length of long chord in m");
L=R*teta*3.14/180;// Length of arc in m
disp(L,"Length of arc in m");
AD=R*(secd(teta/2)-1);// Apex distance in m
disp(AD,"Apex distance in m")
MD=R*(1-cosd(teta/2));// Mid-ordinate in m
disp(MD,"Mid-ordinate in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.4** Length of long chord and length of curve and apex distance an

```
//Example 15_4
clc;
clear;
close;

//Given data
teta=42;// Deflection angle in degree
TD=235.6;// Tangent distance in m
R=TD/tand(teta/2);// Radius of the curve in m
disp(R,"Radius of the curve in m");
l=2*R*sind(teta/2);// Length of long chord in m
disp(l,"Length of long chord in m");
// The answer provided in the textbook is wrong
L=R*teta*3.14/180;// Length of arc in m
disp(L,"Length of arc in m");
AD=R*(secd(teta/2)-1);// Apex distance in m
disp(AD,"Apex distance in m")
MD=R*(1-cosd(teta/2));// Mid-ordinate in m
disp(MD,"Mid-ordinate in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.5** Offsets from the long chord

```
//Example 15_5
clc;
clear;
close;

//Given data
a=20;// Length of arc in m
```

```
d=4*3.14/180;// Degree of curve in radian
R=a/d;// Radius of the curve in m
teta=40;// Deflection angle in degree
l=2*R*sind(teta/2);// Length of long chord in m
disp(l,"Length of long chord in m");
m1=a;// Distance from midpoint in m
m2=a+20;// Distance from midpoint in m
m3=a+40;// Distance from midpoint in m
m4=a+60;// Distance from midpoint in m
m5=l/2;// Distance from midpoint in m
// Using exact formula
disp("Using exact formula");
Y1=sqrt((R^2)-(m1^2))-sqrt((R^2)-((m5)^2));// Length of Offset Y1  in m
disp(Y1,"Length of Offset Y1 from centre in m");
Y2=sqrt((R^2)-(m2^2))-sqrt((R^2)-((m5)^2));// Length of Offset Y2  in m
disp(Y2,"Length of Offset Y2 from centre in m");
Y3=sqrt((R^2)-(m3^2))-sqrt((R^2)-((m5)^2));// Length of Offset Y3 in m
disp(Y3,"Length of Offset Y3 from centre in m");
Y4=sqrt((R^2)-(m4^2))-sqrt((R^2)-((m5)^2));// Length of Offset Y4 in m
disp(Y4,"Length of Offset Y4 from centre in m");
Y5=sqrt((R^2)-(m5^2))-sqrt((R^2)-((m5)^2));// Length of Offset Y5 in m
disp(Y5,"Length of Offset Y5 from centre in m");
x1=l/2;// Distance from tangent point x1 in m
x2=x1-20;// Distance from tangent point x2 in m
x3=x1-40;// Distance from tangent point x3 in m
x4=x1-60;// Distance from tangent point x4 in m
x5=x1-80;// Distance from tangent point x5 in m
// Using approximate formula
disp("Using approximate formula");
Y1=x1*(l-x1)/(2*R);// Length of Offset Y1 in m
disp(Y1,"Length of Offset Y1 in m");
Y2=x2*(l-x2)/(2*R);// Length of Offset Y2 in m
disp(Y2,"Length of Offset Y2 in m");
```

```
// The answers vary due to round off error
```

**Scilab code Exa 15.7** Radial and Perpendicular offsets from tangent

```
//Example 15_7
clc;
clear;
close;

//Given data
x1=20;// Distance along tangent in m
x2=40;// Distance along tangent in m
x3=60;// Distance along tangent in m
x4=80;// Distance along tangent in m
x5=100;// Distance along tangent in m
x6=120;// Distance along tangent in m
R=300;// Radius of the curve in m
disp("Radial offset (exact value)");
Yr1=sqrt((R^2)+(x1^2))-R;// Radial offset Yr1 (exact value) in m
disp(Yr1,"Radial offset Yr1 (exact value) in m");
Yr2=sqrt((R^2)+(x2^2))-R;// Radial offset Yr2 (exact value) in m
disp(Yr2,"Radial offset Yr2 (exact value) in m");
Yr3=sqrt((R^2)+(x3^2))-R;// Radial offset Yr3 (exact value) in m
disp(Yr3,"Radial offset Yr3 (exact value) in m");
Yr4=sqrt((R^2)+(x4^2))-R;// Radial offset Yr4 (exact value) in m
disp(Yr4,"Radial offset Yr4 (exact value) in m");
Yr5=sqrt((R^2)+(x5^2))-R;// Radial offset Yr5 (exact value) in m
disp(Yr5,"Radial offset Yr5 (exact value) in m");
Yr6=sqrt((R^2)+(x6^2))-R;// Radial offset Yr6 (exact value) in m
```

```
disp(Yr6,"Radial offset Yr6 (exact value) in m");

disp("Perpendicular offset (exact value)");
Yp1=R-sqrt((R^2)-(x1^2));// Perpendicular offset Yp1
    (exact value) in m
disp(Yp1,"Perpendicular offset Yp1 (exact value) in
   m");
Yp2=R-sqrt((R^2)-(x2^2));// Perpendicular offset Yp2
    (exact value) in m
disp(Yp2,"Perpendicular offset Yp2 (exact value) in
   m");
Yp3=R-sqrt((R^2)-(x3^2));// Perpendicular offset Yp3
    (exact value) in m
disp(Yp3,"Perpendicular offset Yp3 (exact value) in
   m");
Yp4=R-sqrt((R^2)-(x4^2));// Perpendicular offset Yp4
    (exact value) in m
disp(Yp4,"Perpendicular offset Yp4 (exact value) in
   m");
Yp5=R-sqrt((R^2)-(x5^2));// Perpendicular offset Yp5
    (exact value) in m
disp(Yp5,"Perpendicular offset Yp5 (exact value) in
   m");
Yp6=R-sqrt((R^2)-(x6^2));// Perpendicular offset Yp6
    (exact value) in m
disp(Yp6,"Perpendicular offset Yp6 (exact value) in
   m");

disp("Approximate value of offset");
Ya1=(x1^2)/(2*R);// Offset Ya1 (approximate value)
   in m
disp(Ya1,"Offset Ya1 (approximate value) in m");
Ya2=(x2^2)/(2*R);// Offset Ya2 (approximate value)
   in m
disp(Ya2,"Offset Ya2 (approximate value) in m");
Ya3=(x3^2)/(2*R);// Offset Ya3 (approximate value)
   in m
disp(Ya3,"Offset Ya3 (approximate value) in m");
```

```
Ya4=(x4^2)/(2*R);// Offset Ya4 (approximate value) in m
disp(Ya4,"Offset Ya4 (approximate value) in m");
Ya5=(x5^2)/(2*R);// Offset Ya5 (approximate value) in m
disp(Ya5,"Offset Ya5 (approximate value) in m");
Ya6=(x6^2)/(2*R);// Offset Ya6 (approximate value) in m
disp(Ya6,"Offset Ya6 (approximate value) in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.8** `Radial and Perpendicular offsets from tangent`

```
//Example 15_8
clc;
clear;
close;

//Given data
x1=20;// Distance along tangent in m
x2=40;// Distance along tangent in m
x3=60;// Distance along tangent in m
x4=80;// Distance along tangent in m
x5=100;// Distance along tangent in m
R=800;// Radius of the curve in m
disp("Radial offset (exact value)");
Yr1=sqrt((R^2)+(x1^2))-R;// Radial offset Yr1 (exact value) in m
disp(Yr1,"Radial offset Yr1 (exact value) in m");
Yr2=sqrt((R^2)+(x2^2))-R;// Radial offset Yr2 (exact value) in m
disp(Yr2,"Radial offset Yr2 (exact value) in m");
Yr3=sqrt((R^2)+(x3^2))-R;// Radial offset Yr3 (exact value) in m
disp(Yr3,"Radial offset Yr3 (exact value) in m");
```

```
Yr4=sqrt((R^2)+(x4^2))-R;// Radial offset Yr4 (exact value) in m
disp(Yr4,"Radial offset Yr4 (exact value) in m");
Yr5=sqrt((R^2)+(x5^2))-R;// Radial offset Yr5 (exact value) in m
disp(Yr5,"Radial offset Yr5 (exact value) in m");

disp("Perpendicular offset (exact value)");
Yp1=R-sqrt((R^2)-(x1^2));// Perpendicular offset Yp1 (exact value) in m
disp(Yp1,"Perpendicular offset Yp1 (exact value) in m");
Yp2=R-sqrt((R^2)-(x2^2));// Perpendicular offset Yp2 (exact value) in m
disp(Yp2,"Perpendicular offset Yp2 (exact value) in m");
Yp3=R-sqrt((R^2)-(x3^2));// Perpendicular offset Yp3 (exact value) in m
disp(Yp3,"Perpendicular offset Yp3 (exact value) in m");
Yp4=R-sqrt((R^2)-(x4^2));// Perpendicular offset Yp4 (exact value) in m
disp(Yp4,"Perpendicular offset Yp4 (exact value) in m");
Yp5=R-sqrt((R^2)-(x5^2));// Perpendicular offset Yp5 (exact value) in m
disp(Yp5,"Perpendicular offset Yp5 (exact value) in m");

disp("Approximate value of offset");
Ya1=(x1^2)/(2*R);// Offset Ya1 (approximate value) in m
disp(Ya1,"Offset Ya1 (approximate value) in m");
Ya2=(x2^2)/(2*R);// Offset Ya2 (approximate value) in m
disp(Ya2,"Offset Ya2 (approximate value) in m");
Ya3=(x3^2)/(2*R);// Offset Ya3 (approximate value) in m
```

```
disp(Ya3,"Offset Ya3 (approximate value) in m");
Ya4=(x4^2)/(2*R);// Offset Ya4 (approximate value)
    in m
disp(Ya4,"Offset Ya4 (approximate value) in m");
Ya5=(x5^2)/(2*R);// Offset Ya5 (approximate value)
    in m
disp(Ya5,"Offset Ya5 (approximate value) in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.9** `Offset distances`

```
//Example 15_9
clc;
clear;
close;

//Given data
R=400;// Radius of the curve in m
teta=42;// Deflection angle in degree
i=20;// Chord interval in m
d=2*asind(i/(2*R));// Degree of curve with 20-m
    chord in m
hca= teta/2;;// Half the central angle in degree
// This will give 7 chords
a=7*d;// Angle for seven chords in degree
ba=hca-a;// Balance angle in degree
c0=0;// Chord length c0 in m
c1=i*ba/d;// Chord length c1 in m
c2=i;// Chord length c2 in m
c3=i;// Chord length c3 in m
c4=i;// Chord length c4 in m
c5=i;// Chord length c5 in m
Y1=c1*(c0+c1)/(2*R);// Offset Y1 in m
disp(Y1,"Offset Y1 in m");
Y2=c2*(c1+c2)/(2*R);// Offset Y2 in m
```

```
disp(Y2,"Offset Y2 in m");
Y3=c3*(c2+c3)/(2*R);// Offset Y3 in m
disp(Y3,"Offset Y3 in m");
Y4=c4*(c3+c4)/(2*R);// Offset Y4 in m
disp(Y4,"Offset Y4 in m");
Y5=c5*(c4+c5)/(2*R);// Offset Y5 in m
disp(Y5,"Offset Y5 in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.10** `Point at which new tangent line will intersect the first seg`

```
//Example 15_10
clc;
clear;
close;

//Given data
R=300;// Radius of the curve in m
x=100;// Distance along tangent in m
Yr=sqrt((R^2)+(x^2))-R;// Radial offset Yr in m
disp(Yr,"Radial offset Yr in m");
alpha=acosd(R/(R+Yr))/2;// in degree
ca=2*alpha;// Central angle for chord in degree
T1P=R*ca*3.14/180;// Chord length T1P in m
disp(T1P,"Chord length T1P in m")
T1R=T1P/(2*cosd(alpha));// Chord length T1R in m
disp(T1R,"Chord length T1R in m")
// The answers vary due to round off error
```

**Scilab code Exa 15.15** `Chainage of tangent points and point of intersection`

```
//Example 15_15
clc;
```

```
clear;
close;

//Given data
R=350;// Radius of the curve in m
PR=50;// Length of PR in m
RQ=68;// Length of RQ in m
d=110;// Angle PRQ in degree
PQ=sqrt((PR^2)+(RQ^2)-(2*PR*RQ*cosd(d)));// Length
    of PQ in m
disp(PQ)
P=1138.535;// Chainage of P in m
teta=48;// Angle of deflection in degree
TL=R*tand(teta/2);// Tangent length in m
IQ=133.48;// in m
QT1=TL-IQ;// in m
T1=P+PQ-QT1;// Chainage of T1 in m
disp(T1,"Chainage of T1 in m");
l=R*teta*3.14/180;// Length of arc in m
T2=T1+l;// Chainage of T2 in m
disp(T2,"Chainage of T2 in m");
I=T1+TL;// Chainage of I in m
disp(I,"Chainage of I in m");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 15.18** Radius of curve and tangent lengths

```
//Example 15_18
clc;
clear;
close;

//Given data
QS=410;// Length of QS in m
teta1=58+(45/60);// in degree
```

```
teta2=66+(45/60);// in degree
R=QS/(tand(teta1/2)+tand(teta2/2));// Radius of the
    curve in m
disp(R,"Radius of the curve in m");
PQ=R*tand(teta1/2);// Tangent length PQ in m
disp(PQ,"Tangent length PQ in m");
T1Q=PQ;// Tangent length T1Q in m
disp(T1Q,"Tangent length T1Q in m");
T3Q=T1Q;// Tangent length T3Q in m
disp(T3Q,"Tangent length T3Q in m");
ST2=R*tand(teta2/2);// Tangent length ST2 in m
disp(ST2,"Tangent length ST2 in m");
ST3=R*tand(teta2/2);// Tangent length ST3 in m
disp(ST3,"Tangent length ST3 in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.19** `New radius and New chainage of backward tangent point and in`

```
//Example 15_19
clc;
clear;
close;

//Given data
// As the radius remains same, T1T1'=II'=T2T2'=OO'
l=20;// Length of arc in m
d=3;// Degree of curve in degree
teta=68;// Deflection angle in degree
T2P=10;// Length of T2P in m
u=T2P/sind(teta);// Length of T2T2' in m
R=l/(d*3.14/180);// Radius of the curve in m
disp(R,"Radius of the curve in m");
TL=R*tand(teta/2);// Tangent length in m
T1=183.65;// Chainage of T1 in m
v=T1+u;// Chainage of T1' in m
```

```
disp(v,"Chainage of T1 dash in m")
x=v+TL;// Chainage of I' in m
disp(x,"Chainage of I dash in m");
L=R*teta*3.14/180;// Length of arc in m
y=v+L;// Chainage of T2' in m
disp(y,"Chainage of T2 dash in m")
// The answers vary due to round off error
```

**Scilab code Exa 15.20** New radius and New chainage of backward tangent point and in

```
//Example 15_20
clc;
clear;
close;

//Given data
R=400;// Radius of the curve in m
teta=75;// Angle of deflection in degree
IT2=R*tand(teta/2);// Tangent length IT2 in m
II1=IT2*sind(10)/sind(teta+10);// Length of II' in m
I1T2=IT2*sind(teta)/sind(teta+10);// Length of I'T2 in m
R1=I1T2/tand((teta+10)/2);// New radius R' in m
disp(R1,"New radius R dash in m");
IT1=IT2;
T1I1=I1T2;
T1T1=IT1+II1-T1I1;// Length of T1T1' in m
T1=986.45;// Chainage of T1 in m
CT1=T1+T1T1;// Chainage of T1' in m
disp(CT1,"Chainage of T1 dash in m");
CI=CT1+I1T2;// Chainage of I' in m
disp(CI,"Chainage of I dash in m");
L=R1*(teta+10)*3.14/180;// Length of new arc in m
CT2=CT1+L;// Chainage of T2' in m
disp(CT2,"Chainage of T2 dash in m");
```

```
// The answers vary due to round off error
```

**Scilab code Exa 15.21** New radius and New chainage of tangent point and intersectio

```
//Example 15_21
clc;
clear;
close;

//Given data
d=3.5;// in degree
l=20;// Length of the arc in m
R=l*180/(d*3.14);// Radius of the curve in m
teta1=100;// Deflection angle in degree
teta2=15;// in degree
teta=teta1+teta2;// in degree
IT2=R*tand(teta1/2);// Length of IT2 in m
II1=IT2*sind(teta2)/sind(teta);// Length of II' in m
T1I1=IT2+II1;// Length of T1I' in m
R1=T1I1/tand(teta/2);// New radius of the curve in m
disp(R1,"New radius of the curve R dash in m");
CT1=1163.5;// Chainage of T1 in m
CI=CT1+T1I1;// Chainage of CI' in m
disp(CI,"Chainage of CI dash in m");
L=R1*teta*3.14/180;// Length of new arc in m
CT2=CT1+L;// Chainage of T2' in m
disp(CT2,"Chainage of T2 dash in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.22** Chainages of common tangent point and intersection point and

```
//Example 15_22
clc;
```

```
clear;
close;

//Given data
teta=105;// Deflection angle of compound arc in
    degree
teta1=58;// Deflection angle of first arc in degree
teta2=teta-teta1;// Deflection angle of second arc
    in degree
R1=380;// Radius of first arc in m
R2=520;// Radius of second arc in m
EC=R1*tand(teta1/2);// Length of EC in m
ET1=EC;// Length of ET1 in m
CF=R2*tand(teta2/2);// Length of CF in m
FT2=CF;// Length of FT2 in m
EF=EC+CF;// Length of EF in m
// Applying sine rule to triangle EFI
EI=EF*sind(teta2)/sind(75);// Length of EI in m
FI=EF*sind(teta1)/sind(75);// Length of FI in m
T1I=ET1+EI;// Length of T1I in m
T2I=FT2+FI;// Length of T2I in m
T1=848.55;// Chainage of T1 in m
I=T1+T1I;// Chainage of I in m
disp(I,"Chainage of I in m");
L1=R1*teta1*3.14/180;// Length of first arc in m
L2=R2*teta2*3.14/180;// Length of second arc in m
C=T1+L1;// Chainage of C in m
disp(C,"Chainage of C in m");
T2=C+L2;// Chainage of T2 in m
disp(T2,"Chainage of T2 in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.27** Common radius of arcs

```
//Example 15_27
```

```
clc;
clear;
close;

//Given data
T1T2=200;// Distance between tangent points in m
T2G=20;// Length TG2 in m
teta=2*asind(T2G/T1T2);// Angle in degree
R=(T2G/2)/(1-cosd(teta));// Radius of the arc in m
disp(R,"Radius of the arc in m");
```

**Scilab code Exa 15.28** Chianages of common point of the arcs and the second tangent

```
//Example 15_28
clc;
clear;
close;

//Given data
teta1=180-138.5;// Deflection angle of first curve
    in degree
teta2=180-130.75;// Deflection angle of first curve
    in degree
EF=380;// Length of tangent of both curves in m
R=EF/(tand(teta1/2)+tand(teta2/2));// Radius of arc
    in m
disp(R,"Radius of arc in m");
l1=R*teta1*3.14/180;// length of first arc in m
l2=R*teta2*3.14/180;// length of second arc in m
T1=980;// Chainage of T1 in m
C=T1+l1;// Chainage of C in m
disp(C,"Chainage of C in m");
T2=C+l2;// Chainage of T2 in m
disp(T2,"Chainage of T2 in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.29** Common radius of the arcs and angle of intersection

```
//Example 15_29
clc;
clear;
close;

//Given data
// If O2O1P = teta , then sin(teta)=O2P/O1O2=O2P/2R
teta1=30.25;// Angle at first point in degree
teta2=20.5;// Angle at first point in degree
// O2P=O1E + O2F = R(cos(teta1) + cos(teta2))
// sin(teta) = R(cos(teta1) + cos(teta2))/2R
// R gets cancelled and the eq is sin(teta) = (cos(teta1) + cos(teta2))/2
x=cosd(teta1) + cosd(teta2);
teta=asind(x/2);// Angle in degree
// T1T2 = T1E + EF + FT2 = Rsin(teta1) + (2*sin(teta)) + sin(teta2)
T1T2=680;// Distance between tangent points in m
R=T1T2/(sind(teta1)+(2*sind(teta))+sind(teta2));// Radius of the curve in m
disp(R,"Radius of the curve in m");
AI=teta1-teta2;// Angle of intersection in degree
disp(AI,"Angle of intersection in degree");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 15.31** Chainages and offset at 10 m interval

```
//Example 15_31
clc;
```

```
clear;
close;

//Given data
teta=2*asind(25/220);// Central angle in degree
R=(25/2)/(1-cosd(teta));// Radius of the curve in m
disp(R,"Radius of the curve in m");
L=2*R*sind(teta/2);// Length of the long chord in m
disp(L,"Length of the long chord in m");
x0=0;// Distance from midpoint in m
x1=x0+10;// Distance from midpoint in m
x2=x1+10;// Distance from midpoint in m
x3=x2+10;// Distance from midpoint in m
x4=x3+10;// Distance from midpoint in m
x5=x4+10;// Distance from midpoint in m
x6=L/2;// Distance from midpoint in m
Y1=sqrt((R^2)-(x0^2))-sqrt((R^2)-((L/2)^2));// Offset Y1 from long chord in m
disp(Y1,"Offset Y1 from long chord in m");
Y2=sqrt((R^2)-(x1^2))-sqrt((R^2)-((L/2)^2));// Offset Y2 from long chord in m
disp(Y2,"Offset Y2 from long chord in m");
Y3=sqrt((R^2)-(x2^2))-sqrt((R^2)-((L/2)^2));// Offset Y3 from long chord in m
disp(Y3,"Offset Y3 from long chord in m");
Y4=sqrt((R^2)-(x3^2))-sqrt((R^2)-((L/2)^2));// Offset Y4 from long chord in m
disp(Y4,"Offset Y4 from long chord in m");
Y5=sqrt((R^2)-(x4^2))-sqrt((R^2)-((L/2)^2));// Offset Y5 from long chord in m
disp(Y5,"Offset Y5 from long chord in m");
Y6=sqrt((R^2)-(x5^2))-sqrt((R^2)-((L/2)^2));// Offset Y6 from long chord in m
disp(Y6,"Offset Y6 from long chord in m");
Y7=sqrt((R^2)-(x6^2))-sqrt((R^2)-((L/2)^2));// Offset Y7 from long chord in m
disp(Y7,"Offset Y7 from long chord in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.33** Radius of curve and Length of transition curve and Chainages

```
//Example 15_33
clc;
clear;
close;

//Given data
v=100*1000/3600;// Maximum speed of vehicles in m/s
cr=1/4;// Centrifugal ratio
g=9.81;// Force due to gravity in m/s^2
R=4*v^2/g;// Radius of the circular curve in m
disp(R,"Radius of the circular curve in m");
alpha=0.3;// Rate of change of radial acceleration
   in m/s^3
L=v^3/(alpha*R);// Length of transition curve in m
disp(L,"Length of transition curve in m");
tetad=L/(2*R)*180/3.14;// Spiral angle in degree
teta1=60;// Deflection angle between tangents in
   degree
teta=teta1-(2*tetad);// Central angle of circular
   arc in degree
l=R*3.14*teta/180;// Length of circular arc in m
S=L^2/(24*R);// Shift in m
TL=((R+S)*tand(teta1/2))+(L/2);// Tangent length in
   m
LC=l+(2*L);// Length of combined curve in m
I=1850;// Chainage of I in m
C1=I-TL;// Chainage of beginning of first transition
    curve in m
disp(C1,"Chainage of beginning of first transition
   curve in m");
C2=C1+L;// Chainage of beginning of circular arc in
   m
```

```
disp(C2,"Chainage of beginning of circular arc in m"
    );
C3=C2+l;// Chainage of end of circular arc in m
disp(C3,"Chainage of end of circular arc in m");
C4=C3+L;// Chainage of end of combined curve in m
disp(C4,"Chainage of end of combined curve in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.34** Length of transition curve and Design speed of vehicles and

```
//Example 15_34
clc;
clear;
close;

//Given data
R=300;// Radius of circular curve in m
g=9.81;// Force due to gravity in m/s^2
v1=sqrt(15*g*R/150);// Design speed of vehicles in m
    /s
v=sqrt(15*g*R/150)*3600/1000;// Design speed of
    vehicles in km/hr
disp(v,"Design speed of vehicles in km/hr");
alpha=0.3;// Rate of change of radial acceleration
    in m/s^3
L=v1^3/(alpha*R);// Length of transition curve in m
disp(L,"Length of transition curve in m");
tetad=L/(2*R)*180/3.14;// Spiral angle in degree
disp(tetad,"Spiral angle in degree");
S=L^2/(24*R)*100;// Shift in cm
disp(S,"Shift in cm");
// The answers vary due to round off error
```

**Scilab code Exa 15.36** Chainages at the beginning and end

```
//Example 15_36
clc;
clear;
close;

//Given data
R=600;// Radius of the circular curve in m
L=120;// Length of transition curve in m
S=L^2/(24*R);// Shift in m
teta1=40.5;// Deflection angle between tangents in
   degree
TL=((R+S)*tand(teta1/2))+((L/2)*(1-S/(5*R)));//
   Total tangent length in m
tetad=L/(2*R)*180/3.14;// Spiral angle in degree
teta=teta1-(2*tetad);// Central angle of circular
   arc in degree
l=R*3.14*teta/180;// Length of circular arc in m
S=L^2/(24*R);// Shift in m
LC=l+(2*L);// Length of combined curve in m
I=2050;// Chainage of I in m
C1=I-TL;// Chainage of beginning of first transition
    curve in m
disp(C1,"Chainage of beginning of first transition
   curve in m");
C2=C1+L;// Chainage of beginning of circular arc in
   m
disp(C2,"Chainage of beginning of circular arc in m"
   );
C3=C2+l;// Chainage of end of circular arc in m
disp(C3,"Chainage of end of circular arc in m");
C4=C3+L;// Chainage of end of combined curve in m
disp(C4,"Chainage of end of combined curve in m");
// The answers vary due to round off error
```

**Scilab code Exa 15.41** Chainages of the tangent points and apex of the curve

```
//Example 15_41
clc;
clear;
close;

//Given data
g1=0.6;// Gradient 1
g2=-0.9;// Gradient 2
TG=g1-g2;// Total change in gradient
G=30/0.075;// Rate of change in gradient
L=TG*G;// Length in m
// The curve will be in equal lengths on either side of the apex
D=g1*L/(2*100);// difference in m
DE=D*L/(2*100);// Difference in elevaton in m
RL=1430;// Reduced level of point of intersection in m
RL1=RL-D;// Reduced level of first tangent point in m
RL2=RL-DE;// Reduced level of second tangent point in m
I=985.5;// Chainage of point of intersection in m
C1=I+(L/2);// Chainage of apex of curve in m
disp(C1,"Chainage of apex of curve in m");
C2=C1+(L/2);// Chainage of second tangent point in m
disp(C2,"Chainage of second tangent point in m");
```

**Scilab code Exa 15.44** Length of vertical curve

```
//Example 15_44
```

```
clc;
clear;
close;

//Given data

// Sight distance S=L+(100*(sqrt(h1)+sqrt(h2))^2/M)
// S=1.5*L
g1=0.8;// Gradient 1
g2=-1.2;// Gradient 1
M=g1-g2;
h1=1.13;// Height of eye level of driver in m
h2=h1;// in m
// Rearranging the sight distance eq to 1.5L = L + 100*(sqrt(h1)+sqrt(h2))^2/M)
L=2*100*((sqrt(h1)+sqrt(h2))^2)/M;// Length of vertical curve in m
disp(L,"Length of vertical curve in m");
```

# Chapter 16

# Trigonometric Levelling

**Scilab code Exa 16.1** Reduced level of station P

```
//Example 16_1
clc;
clear;
close;

//Given data :
RLb=380.355;// Rl of benchmark in m
sr=2.785;// Staff reading in m
RLl=RLb+sr;// RL of line of sight in m
D=185;// Distance between the instrument and point P
    in m
alpha=8+(28/60)+(40/3600);// Vertical angle in
    degree
h=D*tand(alpha);// Height of staff mark above line
    of sight in m
RLp=RLl+h-3;// RL of staton P in m
disp(RLp,"RL of staton P in m");
// The answers vary due to round off error
```

**Scilab code Exa 16.2** Reduced level of station points P and Q

```
//Example 16_2
clc;
clear;
close;

//Given data :
RLb=1583.55;// Rl of benchmark in m
sr=1.875;// Staff reading in m
RL1=RLb+sr;// RL of line of sight in m
D1=300;// Distance between the instrument and point P in m
D2=2850;// Distance between the instrument and point Q in m
// For point P
alpha1=4+(30/60)+(0/3600);// Vertical angle at P in degree
h1=D1*tand(alpha1);// Height of staff mark above line of sight at P in m
RLp=RL1+h1-4;// RL of staton P in m
disp(RLp,"RL of staton P in m");
// For point Q
alpha2=7+(34/60)+(30/3600);// Vertical angle at Q in degree
h2=D2*tand(alpha2);// Height of staff mark above line of sight at Q in m
C=0.06375*((D2/1000)^2);// Correction for curvature and refraction in m
RLq=RL1+h1+C-4;// RL of staton Q in m
disp(RLq,"RL of staton Q in m");
```

**Scilab code Exa 16.3** Horizontal distance of P from the stations and elevation of P

```
//Example 16_3
```

```
clc;
clear;
close;

//Given data :
// Let the distance of the instrument station I1
   from P be D
// The distance of I2 form P = D+150
alpha1=30+(30/60);// Vertical angle from I1 in
   degree
alpha2=18+(30/60);// Vertical angle from I2 in
   degree
// h1=D*tan(alpha1), h2=(D+150)*tan(alpha2)
// The two heights are equal, therefore h1= h2
// Rearranging the equation as D=150*tan(alpha2)/(
   tan(alpha1)-tan(alpha2))
D=150*tand(alpha2)/(tand(alpha1)-tand(alpha2));//
   Horizontal distance P in m
disp(D,"Horizontal distance P in m");
h=D*tand(alpha1);// Elevation of P in m
// Corrections for curvature and refraction need not
    to be applied, as the distance is small
RLi=1355.765;// RL of instrument axis in m
RLp=RLi+h-4;// RL of station P in m
disp(RLp,"RL of station P in m");
// The answers vary due to round off error
```

**Scilab code Exa 16.4** Horizontal disatnce and RL of the top of the chimney

```
//Example 16_4
clc;
clear;
close;

//Given data :
```

```
r1=1.35;// Reading at benchmark from station I1 in m
r2=2.15;// Reading at benchmark from station I2 in m
S=r2-r1;// Difference in height of instrument axis in m
alpha1=19+(30/60);// Vertical angle from I1 in degree
alpha2=8+(15/60);// Vertical angle from I2 in degree
// If D is the distance between instrument station 1 and the object , then D*tan(alpha1) = H + S
// H - Height from station 2
// S - Difference between the staff intercepts
// Instrument station 2 is at D+200 m from object
// (D+200)*tan(alpha2) = H
// Equating both the H values gives (D+200)*tan(alpha2) = D*tan(alpha1)-S
// Rearranging the equation as D=((200*tan(alpha2))+S)/(tan(alpha1)-tan(alpha2))
D=((200*tand(alpha2))+S)/(tand(alpha1)-tand(alpha2));// Horizontal distance in m
disp(D,"Horizontal distance in m");
H=(D+200)*tand(alpha2);// Height in m
RLb=1020.375;// RL of benchmark in m
RL=RLb+r2+H;// RL of the top of the chimney in m
disp(RL,"RL of the top of the chimney in m")
// The answers vary due to round off error
```

**Scilab code Exa 16.5** RL and Distance from I1 to point P

```
//Example 16_5
clc;
clear;
close;

//Given data :
D=180;// Distance between the stations in m
```

```
a1=58+(30/60);// Angle PI1I2 in degree
a2=50+(50/60);// Angle PI2I1 in degree
a=180-a1-a2;// Angle in I1PI2 in m
// By sine rule,
//      180/sin(a) = I1P/sin(a1) = I2P/sin(a2)
I1P=180*sind(a2)/sind(a);// Distance from I1 to point P in m
disp(I1P,"Distance from I1 to point P in m");
I2P=180*sind(a1)/sind(a);// Distance from I2 to point P in m
disp(I2P,"Distance from I2 to point P in m");
alpha1=10+(50/60);// Vertical angle from I1 in degree
alpha2=9+(27/60);// Vertical angle from I2 in degree
r1=1.65;// Reading at benchmark from station I1 in m
r2=2.85;// Reading at benchmark from station I2 in m
H=I1P*tand(alpha1);// Height in m
RLb=1085.65;// RL of benchmark in m
RLp=RLb+r1+H;// RL of P in m
disp(RLp,"RL of P in m");
// The answers vary due to round off error
```

---

**Scilab code Exa 16.6** Linear correction and Angular correction

```
//Example 16_6
clc;
clear;
close;

//Given data :
d=980;// Distance in m
// R*sin(1")=30.91
a=30.91;
teta=d/a;// Central angle in seconds
R=6380;// Radius in m
```

```
Cc=((d/1000)^2)/(2*R);// Curvature correction in m
disp(Cc,"Curvature correction in m");
Cr=1/7*Cc;// Correction for refraction in m
CC=Cc-Cr;// Combined Correction in m
Ac=teta/2;// Angular correction in seconds
disp(Ac,"Angular correction in seconds");
Cr1=Cc*1000*d/a;// Correction for refraction in seconds
disp(Cr1,"Correction for refraction in seconds");
CC1=Ac-Cr1;// Combined correction in seconds
disp(CC1,"Combined correction in seconds");
// The answers vary due to round off error
```

**Scilab code Exa 16.7** Angular correction for curvature and refraction and vertical

```
//Example 16_7
clc;
clear;
close;

//Given data :
d=2860;// Distance between station P and station Q in m
// R*sin(1")=30.91
a=30.91;
teta=d/a;// Central angle in seconds
R=6380;// Radius in m
Cc=teta/2;// Curvature correction in seconds
disp(Cc,"Curvature correction in seconds");
Cr=0.07*teta;// Correction for refraction in seconds
disp(Cr,"Correction for refraction in seconds");
CC=Cc-Cr;// Combined correction in seconds
disp(CC,"Combined correction in seconds");
alpha=68-CC;// Corrected angle at P in seconds
// From Cr = teta/2 - (alpha+beta)/2 => (alpha+beta)
```

```
    /2 = teta/2 - Cr
// alpha+beta = 2*(teta/2 - Cr)
beta=(2*((teta/2)-Cr))-alpha;// Angle measured form
    Q in seconds
disp(beta,"Angle measured form Q in seconds");
// The answers vary due to round off error
```

**Scilab code Exa 16.8** Axial signal correction

```
//Example 16_8
clc;
clear;
close;

//Given data :
alpha=2+(34/60)+(35/3600);// Vertical angle from P
    to Q in degree
// R*sin(1")=30.91
a=30.91;
d=2574;// Distance between station P and station Q
    in m
teta=d/a;// Central angle in seconds
teta1=alpha+(teta/3600);// Angle in degree
s=5;// Target height in m
h=1.35;// Height of instrument in m
x=teta/(2*3600);
AC=(s-h)*(cosd(teta1)^2)/(d*cosd(teta/(2*3600)));//
    Axis-signal correction in radian
AC=AC*180/3.14;// Axis-signal correction in degree
M=AC*60;// Axis-signal correction in minute
disp(M,"Axis-signal correction in minute");
CE=alpha-AC;// Corrected angle of elevation in
    degree
CEm=(CE-int(CE))*60;// in minutes
CEs=(CEm-int(CEm))*60;// in seconds
```

```
disp(CEs,int(CEm),int(CE),"Corrected angle of elevation in degree,minutes and seconds respectively");
// The answers vary due to round off error
```

# Chapter 17

# Geodetic Surveying

**Scilab code Exa 17.1** `Strength`

```
//Example 17_1
clc;
clear;
close;

//Given data :
n=3;
s=3;
n1=3;
s1=3;
C=(n-s+1)+(n1-(2*s1)+3);
D=6-2;// There are six angles and sides; two unknown
    base lines are not to be counted
A=70;// Angle A in degree
B=45;// Angle B in degree
a=7;
R=(D-C)*a/D;// Strength of figure
disp(R,"Strength of figure");
```

**Scilab code Exa 17.2** Maximum value of R

```
//Example 17_2
clc;
clear;
close;

//Given data :
e=1/20000;// Probable error
a=log(1);
b=log(1+e);
L=21;// Difference in sixth place
d=1;// in seconds
R=3*L^2/(4*d^2);// Maximum value of R
disp(R,"Maximum value of R");
// The answers vary due to round off error
```

**Scilab code Exa 17.3** 120

```
//Example 17_3
clc;
clear;
close;

//Given data :
n=11;// Total number of lines
s=6;// Total number of stations
os=6;// Number of occupied stations
D=(n*2)-2;
C=(n-s+1)+(n-(2*s)+3);
x=(D-C)/D;// Value of (D-C)/D
disp(x,"Value of (D-C)/D");
```

**Scilab code Exa 17.5** Height of the signal

```
//Example 17_5
clc;
clear;
close;

//Given data :
ue=328;// Uniform elevation in m
me=ue+3;// Minimum elevation of line of sight in m
E1=372;// Elevation of station A in m
E2=458;// Elevation of station B in m
h1=E1-me;// Elevation of A in m
h2=E2-me;// Elevation of B in m
D=72;// Distance between stations A and B in km
D1=sqrt(h1/0.06735);// Distance D1 from A in km
D2=D-D1;// Distance D2 from C in km
H=0.06735*D2^2;// Height of the point in the line of
    sight at B in m
eB=me+H;// Elevation of signal at B in m
HB=eB-E2;// Height of signal at B in m
disp(HB,"Height of signal at B in m");
// The answers vary due to round off error
```

**Scilab code Exa 17.6** Height of signal at B for intervisibility

```
//Example 17_6
clc;
clear;
close;

//Given data :
E1=185;// Elevation of A in m
E2=885;// Elevation of B in m
D=100;// Distance between Stations A and B in km
```

```
D1=3.8533*sqrt(E1);// Distance to visible horizon
    from A in km
AC=42;// Distance of C from A in km
AD=81;// Distance of D from A in km
Ae=D1;// in km
Ce=Ae-AC;// in km
De=AD-Ae;// in km
Be=D-Ae;// in km
Cc1=0.06735*(Ce^2);// in m
Dd1=0.06735*(De^2);// in m
Bb1=0.06735*(Be^2);// in m
Bb=E2-Bb1;// in m
c1c2=Bb*AC/D;// in m
d1d2=Bb*AD/D;// in m
Cc2=c1c2+Cc1;// in m
Dd2=d1d2+Dd1;// in m
Lc=Cc2-310;// Line of sight clears peak C by Lc in m
Ld=655-Dd2;// Line of sight fails to clear peak D by
     Ld in m
H=Ld+3;// Height of line of sight at D in m
HB=H*D/AD;// Height of signal B in m
disp(HB,"Height of signal B in m");
// The answers vary due to round off error
```

**Scilab code Exa 17.7** Height of signal

```
//Example 17_7
clc;
clear;
close;

//Given data :
E1=418.85;// Elevation of A in m
E2=702.63;// Elevation of B in m
D=90;// Distance between Stations A and B in km
```

```
D1=3.8533*sqrt(E1);// Distance to visible horizon from A in km
ip=66;// Intervening peak from A in km
ce=D1-ip;// Distance ce in km
cc1=0.06735*(ce^2);// Height from c to line of sight cc' in m
eb=D-D1;// Distance eb in km
bb1=0.06735*(eb^2);// Distance in bb' in m
Bb1=E2-bb1;// Distance Bb' in m
c1c2=Bb1*ip/D;// in m
H=c1c2+cc1;// Height of line of sight at C in m
Ld=524.6-H;// Line of sight fails to clear peak by Ld in m
h=Ld+3;// Height of line of sight at C in m
HB=h*D/ip;// Height of the signal at B in m
disp(HB,"Height of the signal at B in m");
// The answers vary due to round off error
```

**Scilab code Exa 17.8** Phase correction

```
//Example 17_8
clc;
clear;
close;

//Given data :
r=7;// Radius of the signal in cm
D=8560*100;// Distance between the stations A and B in cm
// (a) The observation was made on the bright portion of the signal
teta=50;// angle in degree
alpha=206205*r*(cosd(teta/2)^2)/D;// Alpha in seconds
disp(alpha,"(a) Alpha in seconds");
```

```
// (b) The observation was made on the bright line
alpha=206205*r*cosd(teta/2)/D;// Alpha in seconds
disp(alpha,"(b) Alpha in seconds");
// The answers vary due to round off error
```

**Scilab code Exa 17.9** True length of a line

```
//Example 17_9
clc;
clear;
close;

//Given data :
l=29.995;// Actual length of tape in m
L=30;// Absolute length of tape in m
Ts=38;// Standardised temperature in degree celcius
Tm=22;// Measured temperature in degree celcius
Cl=l-L;// Correction for absolute length of tape in
   m
alpha=11.6/(10^6);// Coefficient of thermal
   expansion of the material ot the tape in /degree
   celcius
Ct=L*alpha*(Tm-Ts);// Correction for temperature in
   m
TC=-(Cl+Ct);// Total correction in m
l1=8560;// Recorded length of line in m
TCl=TC*l1/L;// Total correction for the line in m
TL=l1-TCl;// True length of the line in m
disp(TL,"True length of the line in m");
// The answers vary due to round off error
```

**Scilab code Exa 17.10** True length of line

```
//Example 17_10
clc;
clear;
close;

//Given data :
Rl=755.385;// Recorded length of line in m
Ts=27;// Standardised temperature in degree celcius
Tm=12;// Measured temperature in degree celcius
alpha=11.6/(10^6);// Coefficient of thermal expansion of the material ot the tape in /degree celcius
Tc=Rl*alpha*(Tm-Ts);// Temperature correction in m
s1=1+(30/60);// Slope 1 in degree
s2=2+(10/60);// Slope 2 in degree
s3=3+(30/60);// Slope 3 in degree
s4=2+(45/60);// Slope 4 in degree
s5=4+(30/60);// Slope 5 in degree
l1=120;// Length of slope for 1 degree 30 minutes in m
l2=248;// Length of slope for 2 degree 10 minutes in m
l3=136;// Length of slope for 3 degree 30 minutes in m
l4=135;// Length of slope for 4 degree 45 minutes in m
l5=Rl-(l1+l2+l3+l4);// Length of slope for 4 degree 30 minutes in m
Cs=(l1*(1-cosd(s1)))+(l2*(1-cosd(s2)))+(l3*(1-cosd(s3)))+(l4*(1-cosd(s4)))+(l5*(1-cosd(s5)));// Correction for slope in m
TC=Tc-Cs;// Total correction in m
TL=Rl+TC;// True length of the line in m
disp(TL,"True length of the line in m");
// The answers vary due to round off error
```

**Scilab code Exa 17.11** Sag correction

```
//Example 17_11
clc;
clear;
close;

//Given data :
A=8/(10^6);// Area of cross section of tape in sq. m
d=78500;// Density of the tape material in N/cubic m
w=A*1*d;// Weight of the tape per meter length in N/m
l=100;// Length of tape in m
n=3;// Number of spans
W=w*l/n;// Weight of tape between supports in N
P=200;// Force of pull in N
SC=n*(l/n)*(W^2)/(24*(P^2));// Sag correction in m
disp(SC,"Sag correction in m");
// The answers vary due to round off error
```

**Scilab code Exa 17.12** Corrected length of tape

```
//Example 17_12
clc;
clear;
close;

//Given data :
L=50;// Length of tape in m
h1=110.385;// Elevation of A in m
h2=110.12;// Elevation of B in m
h=h1-h2;// Difference in elevation of A and B in m
```

```
Cs=h^2/(2*L);// Correction for slope in m
Ts=25;// Standardised temperature in degree celcius
Tm=42;// Measured temperature in degree celcius
alpha=11.6/(10^6);// Coefficient of thermal expansion of the material ot the tape in /degree celcius
Ct=L*alpha*(Tm-Ts);// Temperature correction in m
P=150;// Measured pull in  N
P0=100;// Standard pull in N
A=8/(10^6);// Area of cross section of tape in sq. m
E=2*10^11;// Youngs modulus in GN/sq. m
Cp=(P-P0)^2/(A*E);// Correction for pull in m
d=78500;// Density of the tape material in N/cubic m
w=A*1*d;// Weight of the tape per meter length in N/m
l=100;// Length of tape in m
n=1;// Number of spans
W=w*L/n;// Weight of tape between supports in N
CS=L*W^2/(24*P^2);
TC=Ct-Cs-Cp-CS;//
Cl=L+TC;// Corrected length in m
hm=1163.853;// Height of A above mean sea level in m
R=6370*1000;
Rm=L*hm/R;// Reduction at mean sea level in m
GL=Cl-Rm;// Geodetic length in m
disp(GL,"Geodetic length in m");
// The answers vary due to round off error
```

# Chapter 18

# Theory of Errors and Survey Adjustments

**Scilab code Exa 18.1** Arithmetic mean and Weighted mean

```
//Example 18_1
clc;
clear;
close;

//Given data :
O1=42+(22/60)+(32/3600);// Observation 1 in degree
O2=42+(22/60)+(30/3600);// Observation 2 in degree
O3=42+(22/60)+(33/3600);// Observation 3 in degree
O4=42+(22/60)+(34/3600);// Observation 4 in degree
O5=42+(22/60)+(29/3600);// Observation 5 in degree
O6=42+(22/60)+(30/3600);// Observation 6 in degree
n=6;// Number of observation
Amean=(O1+O2+O3+O4+O5+O6)/n;// Arithmetic mean in
    degree
m=(Amean-int(Amean))*60;// in minutes
s=(m-int(m))*60;// in seconds
disp(s,int(m),int(Amean),"Arithmetic mean in degree,
    minute and seconds respectively");
```

```
// Weight of mean = Number of obseravtions
Wmean=n;// Weight of mean
disp(Wmean,"Weight of mean");
```

**Scilab code Exa 18.2** Weight of the mean

```
//Example 18_2
clc;
clear;
close;

//Given data :
O1=42+(22/60)+(32/3600);// Observation 1 in degree
O2=42+(22/60)+(30/3600);// Observation 2 in degree
O3=42+(22/60)+(33/3600);// Observation 3 in degree
O4=42+(22/60)+(34/3600);// Observation 4 in degree
O5=42+(22/60)+(29/3600);// Observation 5 in degree
O6=42+(22/60)+(30/3600);// Observation 6 in degree
w1=2;// Weight of observation O1
w2=4;// Weight of observation O2
w3=3;// Weight of observation O3
w4=2;// Weight of observation O4
w5=3;// Weight of observation O5
w6=4;// Weight of observation O6
S=w1+w2+w3+w4+w5+w6;// Sum of weight of observations
Amean=((O1*w1)+(O2*w2)+(O3*w3)+(O4*w4)+(O5*w5)+(O6*
    w6))/S;// Arithmetic mean in degree
m=(Amean-int(Amean))*60;// in minutes
s=(m-int(m))*60;// in seconds
disp(s,int(m),int(Amean),"Arithmetic mean in degree,
    minute and seconds respectively");
// Weight of mean = Sum of weight of observations
Wmean=S;// Weight of mean
disp(Wmean,"Weight of mean");
// The answers vary due to round off error
```

**Scilab code Exa 18.3** Values and weights

```
//Example 18_3
clc;
clear;
close;

//Given data :
A=32+(16/60)+(18/3600);// Observation A in degree
wa=3;// Weight of A
B=26+(14/60)+(12/3600);// Observation B in degree
wb=2;// Weight of B
S=A+B;// Sum of angles in degree
D=A-B;// Difference between angles in degree
W=1/((1/wa)+(1/wb));// Weight of the mean
disp(W,"Weight of the mean");
```

**Scilab code Exa 18.4** Weight

```
//Example 18_4
clc;
clear;
close;

//Given data :
A=42+(22/60)+(31.33/3600);// Observation A in degree
wa=6;// Weigth of A
W1=wa/(3^2);// Weight of 3A
disp(W1,"Weight of 3A");
W2=wa*(4^2);// Weight of A/4
disp(W2,"Weight of A/4");
```

**Scilab code Exa 18.5** Value and Weight of C

```
//Example 18_5
clc;
clear;
close;

//Given data :
A=42+(32/60)+(40/3600);// Observation A in degree
wa=3;// Weight of A
B=51+(29/60)+(20/3600);// Observation B in degree
wb=2;// Weight of B
C=180-(A+B);// Observation C in degree
m=(C-int(C))*60;// in minutes
disp(int(m),int(C),"Observation C in degree and
    minute respectively");
W1=1/((1/wa)+(1/wb));// Weight of A+B
W2=W1;// Weight of C
disp(W2,"Weight of C")
// The answers vary due to round off error
```

**Scilab code Exa 18.6** Most probable value of the angle

```
//Example 18_6
clc;
clear;
close;

//Given data :
O1=36+(22/60)+(40/3600);// Observation 1 in degree
O2=36+(22/60)+(44/3600);// Observation 2 in degree
O3=36+(22/60)+(42/3600);// Observation 3 in degree
```

```
O4=36+(22/60)+(50/3600);// Observation 4 in degree
O5=36+(22/60)+(38/3600);// Observation 5 in degree
O6=36+(22/60)+(46/3600);// Observation 6 in degree
n=6;// Number of observation
P=(O1+O2+O3+O4+O5+O6)/n;// Most probable value P in
    degree
m=(P-int(P))*60;// in minutes
s=(m-int(m))*60;// in seconds
disp(s,int(m),int(P),"Most probable value P in
    degree,minute and seconds respectively");
```

**Scilab code Exa 18.7** `Most probable value`

```
//Example 18_7
clc;
clear;
close;

//Given data :
O1=36+(22/60)+(40/3600);// Observation 1 in degree
O2=36+(22/60)+(44/3600);// Observation 2 in degree
O3=36+(22/60)+(42/3600);// Observation 3 in degree
O4=36+(22/60)+(50/3600);// Observation 4 in degree
O5=36+(22/60)+(38/3600);// Observation 5 in degree
O6=36+(22/60)+(46/3600);// Observation 6 in degree
w1=1;// Weight of observation O1
w2=2;// Weight of observation O2
w3=4;// Weight of observation O3
w4=3;// Weight of observation O4
w5=2;// Weight of observation O5
w6=3;// Weight of observation O6
s=w1+w2+w3+w4+w5+w6;// Sum of weight of observations
Amean=((O1*w1)+(O2*w2)+(O3*w3)+(O4*w4)+(O5*w5)+(O6*
    w6))/s;// Weighted arithmetic mean in degree
m=(Amean-int(Amean))*60;// in minutes
```

```
s=(m-int(m))*60;// in seconds
disp(s,int(m),int(Amean),"Weighted arithmetic mean
   in degree,minute and seconds respectively");
```

**Scilab code Exa 18.21** Probable error in area of the triangle

```
//Example 18_21
clc;
clear;
close;

//Given data :
ea=0.015;// in m
eb=0.02;// in m
a=90;// Side of triangle in m
b=120;// Side of triangle in m
eA=sqrt(((ea*b/2)^2)+((eb*a/2)^2));// eA in sq. m
// Area A = a*b
A=a*b;// Area in sq. m
disp(A,"Area in sq. m");
P1=A+eA;// Probable value P1 in sq. m
disp(P1,"Probable value P1 in sq. m");
P2=A-eA;// Probable value P2 in sq. m
disp(P2,"Probable value P2 in sq. m");
// The answers vary due to round off error
```

# Chapter 19

# Hydrographic Surveying

**Scilab code Exa 19.1** Coordinates of S

```
//Example 19_1
clc;
clear;
close;

//Given data :
teta1=42+(32/60);// Angle SPQ in degree
teta2=64+(36/60);// Angle SQP in degree
PQ=1580;// Distance PQ in m
x=PQ*tand(teta2)/(tand(teta1)+tand(teta2));//
    Coordinate x in m
disp(x,"Coordinate x")
y=x*tand(teta1);// Coordinate y in m
disp(y,"Coordinate y")
disp(y,x,"Coordinates of S(x,y) are");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 19.2** Coordinates of S

```
//Example 19_2
clc;
clear;
close;

//Given data :
teta1=76+(42/60);// Angle SPQ in degree
teta2=32+(56/60);// Angle PSQ in degree
teta3=180-(teta1+teta2);// Angle PQS in degree
PQ=934;// Distance PQ in m
x=PQ*tand(teta3)/(tand(teta3)+tand(teta1));// Coordinate x in m
disp(x,"Coordinate x")
y=x*tand(teta1);// Coordinate y in m
disp(y,"Coordinate y")
disp(y,x,"Coordinates of S(x,y) are");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 19.3** Corrected soundings referred to the datum

```
//Example 19_3
clc;
clear;
close;

//Given data :
g1=6.85;// Gauge reading at 10.00 am in m
g2=6.95;// Gauge reading at 10.10 am in m
dg=1;// Datum gauge reading in m
mg=(g1+g2)/2;// Mean gauge reading at 10.05 am in m
C=-(mg-dg);// Correction in m
s1=2.35;// Sounding s1 at 10.05 am in m
s2=7.65;// Sounding s2 at 10.05 am in m
Cs1=C+s1;// Corrected sounding for s1 in m
disp(Cs1,"Corrected sounding for s1 in m");
```

```
Cs2=C+s2;// Corrected sounding for s2 in m
disp(Cs2,"Corrected sounding for s2 in m");
// The answers vary due to round off error
// The answer provided in the textbook is wrong
```

# Chapter 21

# Astronomical Surveying

**Scilab code Exa 21.1** Difference of latitudes between two points

```
//Example 21_1
clc;
clear;
close;

//Given data :
// (a) 28degree 35minutes N, 58degree 36minutes N
L1=28+(35/60);// Latitude 1 in degree
L2=58+(36/60);// Latitude 2 in degree
// The latitudes are measured towards the same pole
// The difference in laditude between two points is
   the difference in latitudes of the two points
D1=L2-L1;// Difference in latitude in degree
deg=int(D1);// degree
mins=(D1-deg)*60;// minutes
disp("(a) Difference of Latitude");
disp(deg,"Degree");
disp(mins,"Minutes");

// (b) 18degree 24minutes N, 34degree 45minutes S
L1=18+(24/60);// Latitude 1 in degree
```

```
L2=34+(45/60);// Latitude 2 in degree
// The latitudes are measured towards the same pole
// The difference in laditude between two points is the sum of the latitudes of the two points
D1=L2+L1;// Sum of latitude in degree
deg=int(D1);// degree
mins=(D1-deg)*60;// minutes
disp("(b) Difference of Latitude");
disp(deg,"Degree");
disp(mins,"Minutes");
```

**Scilab code Exa 21.2** Difference of longitude between two points

```
//Example 21_2
clc;
clear;
close;

//Given data :
// (a) 38degree 25minutes W, 28degree 12minutes W
L1=38+(25/60);// Longitude 1 in degree
L2=28+(12/60);// Longitude 2 in degree
// The longitudes are measured towards the same pole
// The difference in longitude between two points is the difference in longitude of the two points
D1=L1-L2;// Difference in longitude in degree
deg=int(D1);// degree
mins=(D1-deg)*60;// minutes
disp("(a) Difference of Longitude");
disp(deg,"Degree");
disp(mins,"Minutes");

// (b) 19degree 24minutes E, 23degree 48minutes W
L1=19+(24/60);// Longitude 1 in degree
L2=23+(48/60);// Longitude 2 in degree
```

```
// The longitudes are measured towards the same pole
// The difference in longitude between two points is the sum of the longitude of the two points
D1=L1+L2;// Sum of longitude in degree
deg=int(D1);// degree
mins=(D1-deg)*60;// minutes
disp("(b) Difference of Longitude");
disp(deg,"Degree");
disp(mins,"Minutes");
```

**Scilab code Exa 21.3** `Distance between two points`

```
//Example 21_3
clc;
clear;
close;

//Given data :
// 36degree 24minutes N, 30degree 36minutes W
L1=36+(24/60);// Latitude of A in degree
l1=30+(36/60);// Longitude of A degree
// 12degree 12minutes N, 15degree 20minutes E
L2=12+(12/60);// Latitude of B in degree
l2=15+(20/60);// Longitude of B degree
// The longitudes are measured towards the same pole
// The difference in longitude between two points is the difference in longitude of the two points
D1=l1+l2;// Difference in longitude in degree
deg=int(D1);// degree
mins=(D1-deg)*60;// minutes
disp("Difference of Longitude");
disp(deg,"Degree");
disp(mins,"Minutes");
D=D1*60*cosd(L1);// Departure in NM
D=D*1.852;// Departure in km
```

```
disp(D,"Departure in km");
// The answers vary due to round off error
```

**Scilab code Exa 21.4** Shortest distance between two points

```
//Example 21_4
clc;
clear;
close;

//Given data :
// 18degree 24minutes N, 36degree 18minutes E
L1=18+(24/60);// Latitude of A in degree
l1=36+(18/60);// Longitude of A degree
// 68degree 32minutes N, 126degree 34minutes E
L2=68+(32/60);// Latitude of B in degree
l2=126+(34/60);// Longitude of B degree
PA=90-L1;// Latitude PA in degree
PB=90-L2;// Latitude PB in degree
// The longitudes are measured towards the same pole
// The difference in longitude between two points is the difference in longitude of the two point
APB=l2-l1;// Difference in longitude in degree
AB=acosd((cosd(PA)*cosd(PB))+(sind(PA)*sind(PB)*cosd(APB)));// Angle AB in degree
R=6370;// Radius in km
D=R*AB*3.14/180;// Distance AB in km
disp(D,"Distance AB in km");
// The answer provided in the textbook is wrong
```

**Scilab code Exa 21.8** Latitude of the place of observation

```
//Example 21_8
```

```
clc;
clear;
close;

//Given data :
A=56;// Azimuth of the place in degree
d=42+(15/60);// Declination in degree
// In astronomical triangle ZPS
PS=90-d;// PS in degree
// The triangle is right angled at S. Therefore
// sin(A)=cos(d)/cos(teta)
// cos(teta)=cos(d)/sin(A)
teta=acosd(cosd(d)/sind(A));// Latitude in degree
m=(teta-int(teta))*60;// in minutes
s=(m-int(m))*60;// in seconds
disp(s,int(m),int(teta),"Latitude in degree,minute
    and seconds respectively");
// The answers vary due to round off error
```

**Scilab code Exa 21.9** Declination of star and Latitude of the place

```
//Example 21_9
clc;
clear;
close;

//Given data :

// (a) At upper culmination
d=20;// Declination in degree
teta=50;// Latitude in degree
ZD1=teta-d;// Zenith distance at upper culmination
    in degree
disp(ZD1,"(a) Zenith distance at upper culmination
    in degree");
```

```

// (b) At lower culmination
d=22+(30/60);// Declination in degree
teta=45+(30/60);// Latitude in degree
ZD2=180-teta-d;// Zenith distance at lower culmination in degree
disp(ZD2,"(b) Zenith distance at lower culmination in degree");
```

**Scilab code Exa 21.20** `Position of the star between the zenith and the equator`

```
//Example 21_20
clc;
clear;
close;

//Given data :
alpha1=69+(32/60)+(31.8/3600);// Observed altitude in degree
cr=57*cotd(alpha1);// Correction for refraction in seconds
alpha2=alpha1-(cr/3600);// Corrected altitude in degree
ZD=90-alpha2;// Zenith distance in degree
// As the star lies between the zenith and the equator
d=48+(26/60)+(38.31/3600);// Declination in degree
teta=ZD+d;// Latitude in degree
m=(teta-int(teta))*60;// in minutes
s=(m-int(m))*60;// in seconds
disp(s,int(m),int(teta),"Latitude in degree,minute and seconds respectively");
// The answers vary due to round off error
```