Scilab Textbook Companion for Engineering Physics - I by G. SenthilKumar[1]

Created by
Kadirisani Charan
B.tech
Electrical Engineering
Sastra University
College Teacher
Raju N
Cross-Checked by
Chaitanya

June 1, 2016

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

Book Description

Title: Engineering Physics - I

Author: G. SenthilKumar

Publisher: VRB Publishers, Chennai

Edition: 1

Year: 2011

ISBN: 9789380241852

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

Ultrasonics

Scilab code Exa 1.a.1 calculating fundamental frequency

```
1 // Chapter 1 addl_Example 1
2 //
   ================================================================================

3 clc;
4 clear;
5
6 //input data
7
8 P            = 1;              // for fundamental mode
9 t            = 1.5*10^-3;      // thickness of quartz
     crystal
10 E           = 7.9*10^10       // young's modulus in N/
     m^2
11 p           = 2650            // density in kg/m^3
12
13 //Calculations
14
15 f            = (P/(2*t))*sqrt(E/p);       // frequency
      of the oscillator circuit
16
```

```
17 //Output
18 mprintf('The Fundamental Frequency of the Quartz
      crystal = %3.4f MHz',f/10^6);
19
20 //
```

Scilab code Exa 1.a.2 Finding Thickness

```
1 // Chapter 1 addl_Example 2
2 //

3 clc;
4 clear;
5
6 //input data
7
8 v        = 5000;          // velocity of ultrasonics
      in m/s
9 df       = 60*10^3;       // difference b/w two
      adjacent harmonic freq. in Hz
10
11 //Calculations
12
13 d        = v/(2*df)  ;        // thickness of steel
      plate
14
15 //Output
16 mprintf('The thickness of steel plate = %f m',d);
17
18 //
```

Scilab code Exa 1.a.3 Finding depth of submerged submarine

```
1 // Chapter 1 addl_Example 3
2 //
   ================================================================================

3 clc;
4 clear;
5
6 //input data
7
8 v        = 1440;          // velocity of ultrasonics
     in  sea water in m/s
9 t        = 0.33           // time taken b/w tx and rx
     in sec
10
11 //Calculations
12
13 d        = v*t;           // distance travelled by
     ultrasonics
14 D        = d/2;           // depth of submerged
     submarine in m
15
16 //output
17 mprintf('Depth of submerged submarine = %3.1f m',D);
18
19 //
   ================================================================================
```

Scilab code Exa 1.a.4 Finding velocity of ultrasonics

```
// Chapter 1 addl_Example 4
//
================================================================================

clc;
clear;

//input data

d             = 0.55*10^-3;          // distance b/w two
    antinodes
f             = 1.5*10^6;           // freq of the
    crystal

//Calculations

lamda         = 2*d;                // wavelength
v             = f*lamda;            // velocity of
    ultronics

//Output
mprintf('Velocity of waves in sea water = %3.0f m/s'
    ,v);

//
================================================================================
```

Scilab code Exa 1.a.5 Finding Youngs modulus and thickness of crystal

```
// Chapter 1 addl_Example 5
//
================================================================================

clc;
```

```
4  clear;
5
6  //input data
7
8  P            = 1;              // for fundamental mode
9  p            = 2660            // density of quartz in
       kg/m^3
10 f            = 1300*10^3       // freq of quartz plate
       for sub division ii
11 k            = 2.87*10^3
12 //f1         = (k)/t   // freq for sub division i
13
14 //Calculations
15
16 //f            = (P/(2*t))*sqrt(E/p);
17 E              = p*4*(k)^2;       //Youngs modulus in
       N/m^2
18 t            = (P/(2*f))*sqrt(E/p);
19
20
21 //Output
22 mprintf('Youngs modulus of quartz plate = %e Nm^-2\n
       Thickness of the crystal = %e m',E,t);
23
24 //
```

Scilab code Exa 1.1 Calculating frequency of the Oscillator

```
1  // Chapter 1 Example 1
2  //
```

```
3  clc;
```

```
4  clear;
5
6  //input data
7
8  P            = 1;              // for fundamental mode
9  t            = 0.1*10^-2;      // thickness of piezo
       electric crystal
10 E            = 80*10^9         // young's modulus
11 p            = 2654            // density in kg/m^3
12
13 //Calculations
14
15 f            = (P/(2*t))*sqrt(E/p);       // frequency
       of the oscillator circuit
16
17 //Output
18 mprintf('The Frequency of the oscillator circuit =
       %e Hz',f);
19
20 //
```

Scilab code Exa 1.2 Calculating Frequency of the vibrating crystal

```
1  // Chapter 1 Example 2
2  //
3  clc;
4  clear;
5
6  //input data
7
8  P            = 1;              // for fundamental mode
```

```
t            = 0.1*10^-2;     // thickness of piezo
   electric crystal
E            = 7.9*10^10      // young's modulus
p            = 2650           // density in kg/m^3

//Calculations

f            = (P/(2*t))*sqrt(E/p);       // frequency
    of the oscillator circuit

//Output
mprintf('The Frequency of the vibrating crystal = %3
   .3f MHz',f/10^6);

//
```

Scilab code Exa 1.3 Finding velocity of ultrasonic wave

```
// Chapter 1 Example 3
//


clc;
clear;

//input data

f        = 1.5*10^6;          //frequency of
   ultrasonics in Hz
d6       = 2.75*10^-3;        // distance between 6
   consecutive nodes

//Calculations
```

```
d        = d6/5;                // distance b/w two
   nodes
lamda    = 2*d;                 // wavelength in m
v        = f*lamda;             // velocity of
   ultrasonics

//Output
mprintf('Velocity of ultrasonics  = %3.0f m/sec',v);

//
```

Chapter 2

Laser

Scilab code Exa 2.a.1 Finding Energy of first Excited State

```
1 // Chapter 2 addl_Example 1
2 //
  ================================================================================

3 clc;
4 clear;
5
6 //input data
7 h            = 6.625*10^-34;          // planck's
     constant
8 c            = 3*10^8;                // vel. of light
      in m/s
9 lamda        = 5890*10^-10;           // wavelength of
      light in m
10 q           = 1.6*10^-19;            // charge of
     electron
11
12
13 //Calculations
14 Eg           = (h*c)/lamda;           // energy in
     joules
```

```
15 E            = Eg/q                      // energy in eV
16
17 //Output
18
19 mprintf('Energy of the first excited state  = %3.3f
      eV',E);
20
21 //
```

Scilab code Exa 2.a.2 Finding ratio of stimulated emission to spontaneous emission

```
1  // Chapter 2 addl_Example 2
2  //
3  clc;
4  clear;
5
6  //input data
7  h            = 6.625*10^-34;          // planck's
      constant
8  c            = 3*10^8;                // vel. of light
       in m/s
9  lamda        = 5890*10^-10;           // wavelength of
       light in m
10 k            = 1.38*10^-23;           // Boltzmann
      constant
11 Tc           = 280                    // Temperature
      in centigrades
12
13 //Calculations
14 T            = Tc+273;                // temperature
```

```
    in kelvin
15 R            = 1/((exp((h*c)/(k*T*lamda))) - 1);
    // ratio of stimulated emission to spontaneous
    emission
16
17 //Output
18
19 mprintf('The ratio between the stimulated emission
    and apontaneous emission = %3.3e',R);
20
21 //
```

Scilab code Exa 2.a.3 Finding Number of photons emitted

```
1 // Chapter 2 addl_Example 3
2 //

3 clc;
4 clear;
5
6 //input data
7 h              = 6.625*10^-34;          // planck's
    constant
8 c              = 3*10^8;                // vel. of light
     in m/s
9 lamda          = 6328*10^-10;           // wavelength of
     He-Ne laser source in m
10 q             = 1.6*10^-19;            // charge of
    electron
11 P             = 3*10^-3                // output power
    of the He-Ne source in watts or J/sec
12
```

```
13
14 //Calculations
15 v            = c/lamda                  // frequency of
      the photon emitted by the laser beam
16 E            = h*v;                     // energy of a
      photon in joules
17 Po           = P*60;                    // conversion
      fro J/sec to J/min
18 N            = Po/E;                    // No of photons
       emitted per minute
19
20 //Output
21
22 mprintf('The No. of Photons emitted per minute = %3
      .3e photons/minute',N);
23
24 //
```

Scilab code Exa 2.a.4 Finding no of photons emitted

```
1 // Chapter 2 addl_Example 4
2 //


3 clc;
4 clear;
5
6 //input data
7 h            = 6.625*10^-34;            // planck's
      constant
8 c            = 3*10^8;                  // vel. of light
       in m/s
9 lamda        = 9.6*10^-6;               // wavelength of
```

```
    CO2 laser source in m
10 q            = 1.6*10^-19;           // charge of
   electron
11 P            = 10*10^3               // output power
   of the CO2 laser source in watts or J/sec
12
13
14 //Calculations
15 v            = c/lamda               // frequency of
   the photon emitted by the laser beam
16 E            = h*v;                  // energy of a
   photon in joules
17 Po           = P*60*60;              // conversion
   fro J/sec to J/hour
18 N            = Po/E;                 // No of photons
    emitted per hour
19
20 //Output
21
22 mprintf('The No. of Photons emitted per hour = %3.3e
    photons/hour',N);
23
24 //
```

Scilab code Exa 2.a.5 Examining possibility of MASER action

```
1 // Chapter 2 addl_Example 5
2 //


3 clc;
4 clear;
5
```

```
6 //input data
7 h            = 6.625*10^-34;          // planck's
     constant
8 c            = 3*10^8;                // vel. of light
     in m/s
9 lamda        = 10*10^-2;              // wavelength
     for microwave region in m
10 T           = 300                    // Temperature
     in Kelvin
11 Kb          = 1.38*10^-23            // Boltzmann
     constant
12
13 // Calculations
14 // let R    = Rsp/Rst
15 R           = exp((h*c)/(lamda*Kb*T)) - 1;      //
     ratio of spontaneous to stimulated emission
16 if R<1 then
17     mprintf('Since the spontaneous emission is
        lesser than stimulated emission \n hence
        MASER action is possible at thermal
        equilibrium' )
18 end
19 //
```

Scilab code Exa 2.a.6 Possibility of Laser action in optical frequencies

```
1 // Chapter 2 addl_Example 6
2 //


3 clc;
4 clear;
5
```

```
6 //input data
7 h            = 6.625*10^-34;          // planck's
     constant
8 c            = 3*10^8;                // vel. of light
     in m/s
9 lamda        = 5000*10^-10;           // wavelength
     for optical region in m
10 T           = 300                    // Temperature
     in Kelvin
11 Kb          = 1.38*10^-23            // Boltzmann
     constant
12
13 // Calculations
14 // let R    = Rsp/Rst
15 R           = exp((h*c)/(lamda*Kb*T)) - 1;      //
     ratio of spontaneous to stimulated emission
16 if R<1 then
17     mprintf('Since the spontaneous emission is
         lesser than stimulated emission \n hence
         LASER action is possible at thermal
         equilibrium' )
18 else
19
20     mprintf('Since the spontaneous emission is more
         predominant than stimulated emission \n hence
          LASER action is not possible at optical
         frequencies under thermal equilibrium' )
21 end
22
23 //
```

Scilab code Exa 2.a.7 Finding Energy

```
1 // Chapter 2 Additional Example 7
2 //
   ================================================================================

3 clc;
4 clear;
5
6 //input data
7 h            = 6.625*10^-34;          // plank's
     constant
8 c            = 3*10^8;                // vel. of light
      in m/s
9 lamda        = 5511.11*10^-10;        // wavelength of
      green LED light in m
10 q           = 1.6*10^-19;            // charge of
     electron
11
12 //Calculations
13 Eg           = (h*c)/lamda;           // band gap
     energy in joules
14 E            = Eg/q                   // bang gap
     energy in eV
15
16 //Output
17
18 mprintf('Energy bandgap Eg    = %3.2f eV',E);
19
20 //
   ================================================================================
```

Scilab code Exa 1.1 Calculating Number of electron hole pairs

```
1 // Chapter 2 Example 1
2 //
```

```
clc;
clear;

//input data

A            = 4*10^-6;                  // Receiving
   area of photo detector
I            = 200;                      // Intensity in
   W/m^2
h            = 6.625*10^-34;             // plank's
   constant
c            = 3*10^8;                   // vel. of light
    in m/s
lamda        = 0.4*10^-6;                // wavelength of
    light in m

//Calculations
v            = c/lamda;                  // frequency
NOP          = I*A/(h*v)                 // number of
   photons

//since each photon generates an electron hole pair,
    the number of photons is equal to number of
   electron hole pairs

//Output

mprintf('Number of electron hole pairs = %e ',NOP);

//
```

Scilab code Exa 1.2 Calculating Wavelength

```
1 // Chapter 2 Example 1
2 //
  ================================================================================

3 clc;
4 clear;
5
6 //input data
7 Eg           = 2.8;                    // bandgap
     energy in eV
8 h            = 6.625*10^-34;           // plank's
     constant
9 c            = 3*10^8;                 // vel. of light
      in m/s
10 q           = 1.602*10^-19;           // charge of
     electron
11
12 //Calculations
13 E           = Eg*q                   // eV to joules
     conversion
14 lamda       = h*c/E;                  // wavelength
15
16 //Output
17
18 mprintf('wavelength = %3.1f    (Blue Colour)',lamda
     *10^10);
19
20 //
  ================================================================================
```

Scilab code Exa 1.3 Finding Energy Band gap

```
1 // Chapter 2 Example 3
2 //
   ================================================================================

3 clc;
4 clear;
5
6 //input data
7 h            = 6.625*10^-34;          // plank's
     constant
8 c            = 3*10^8;                // vel. of light
      in m/s
9 lamda        = 1.55*10^-6;            // wavelength of
      light in m
10 q           = 1.6*10^-19;            // charge of
     electron
11
12 //Calculations
13 Eg           = (h*c)/lamda;           // band gap
     energy in joules
14 E            = Eg/q                   // bang gap
     energy in eV
15
16 //Output
17
18 mprintf('Energy bandgap Eg    = %3.4f eV',E);
19
20 //
   ================================================================================
```

Scilab code Exa 2.4 Finding number of photons

```
1 // Chapter 2 Example 4
2 //
```

```
3 clc;
4 clear;
5
6 //input data
7 h            = 6.625*10^-34;          // plank's
     constant
8 c            = 3*10^8;                // vel. of light
      in m/s
9 lamda        = 4961*10^-10;           // wavelength of
      light in m
10
11 //Calculations
12 E            = (h*c)/lamda;           // energy in
     joules
13 N            = 1/E
14 //Output
15
16 mprintf('Number of photons required to do one Joule
     of work  = %3.4e /m^3',N);
17
18 //
```

Scilab code Exa 2.5 Calculating Long Wavelength

```
1 // Chapter 2 Example 5
2 //
3 clc;
4 clear;
5
```

```
6 //input data
7 E           = 0.02;                  // ionisation
     energy in eV
8 h           = 6.625*10^-34;          // plank's
     constant
9 c           = 3*10^8;                // vel. of light
      in m/s
10 q          = 1.6*10^-19;            // charge of
     electron
11
12 //Calculations
13
14 lamda       = h*c/(E*q)              // long
     wavelength limit in m
15
16 //Output
17
18 mprintf('long wavelength limit = %3.3e m',lamda);
19
20 //
```

Scilab code Exa 2.6 Finding Wavelength

```
1 // Chapter 2 Example 6
2 //

3 clc;
4 clear;
5
6 //input data
7 E           = 1.44;                  // Bandgap
     energy in eV
```

```
8  h            = 6.625*10^-34;          // plank's
       constant
9  c            = 3*10^8;                // vel. of light
       in m/s
10 q            = 1.6*10^-19;            // charge of
       electron
11
12 //Calculations
13
14 lamda         = h*c/(E*q)              // Wavelength of
       GaAs laser
15
16 //Output
17
18 mprintf('Wavelength of GaAs laser = %3.1f    ',lamda
       *10^10);
19
20 //
```

Chapter 3

Fibre Optics And Applications

Scilab code Exa 3.a.1 Finding Refractive index acceptance angle and max no of modes

```
1 // Chapter 3 Additional Example 1
2 //
  ================================================================================

3 clc;
4 clear;
5
6 //input data
7 n1      = 1.5;        // Refractive index of core
8 NA      = 0.26;       // Numerical aperture
9 d       = 100*10^-6   // core diameter
10 lamda   = 10^-6;      // wavelength in m
11
12 // Calculations
13 n2      = sqrt( n1^2 - NA^2);       // Refractive
     index of cladding
14 im      = asin(NA);                 // Acceptance
     angle
15 im_d    = im*180/%pi                // radian to
     degree conversion
```

```
16 N        = 4.9*(d*NA/lamda)^2;        // maximum no of
       modes
17
18 // Output
19 mprintf('Refractive index of cladding n2 = %3.4f\n
       Acceptance angle = %3.2f degrees\n Maximum number
       of modes that fibre allows = %d ',n2,im_d,N);
20 //
```

Scilab code Exa 3.a.2 Finding Critical angle

```
1 // Chapter 3 Additional Example 2
2 //

3 clc;
4 clear;
5
6 //input data
7 delta       = 0.02;          // relative refractive
      index
8 n1          = 1.48;          // refractive index of
      core
9
10 // Calculations
11 NA          = n1*(2*delta)^0.5;      // Numerical
      aperture
12 n2          = sqrt( n1^2 - NA^2);    // Refractive
      index of cladding
13 cri_ang     = asin(n2/n1);           // critical
      angle
14 cri_ang_d   = cri_ang*180/%pi;       // critical
      angle in degrees
```

```
15
16 // output
17 mprintf('Numerical Aperture = %3.3f\n The Critical
      angle = %3.2f degrees',NA,cri_ang_d);
18 //
```

Scilab code Exa 3.a.3 Calculating Refractive indices of core and cladding

```
1 // Chapter 3 Additional Example 3
2 //

3 clc;
4 clear;
5
6 //input data
7 delta        = 0.015;          // relative refractive
      index
8 NA           = 0.27;           // Numerical aperture
9
10 // Calculations
11 //we know that NA = n1*sqrt(2*  )
12 n1           = NA/sqrt(2*delta)       // refractive
      index of core
13 n2           = sqrt( n1^2 - NA^2);    // Refractive
      index of cladding
14 // Output
15 mprintf('Refractive index of the core = %3.3f\n
      Refractive index of the cladding = %3.3f\n',n1,n2
      );
16 //
```

Scilab code Exa 3.a.4 Calculating no of modes in a fibre

```
1 // Chapter 3 Additional Example 4
2 //
   ================================================================================


3 clc;
4 clear;
5
6 //input data
7 NA       = 0.25;       // Numerical aperture
8 d        = 60*10^-6    // core diameter
9 lamda    = 2.7*10^-6; // wavelength in m
10
11 // calculations
12 N        = 4.9*(d*NA/lamda)^2;        // no of modes
   for step index fibre
13
14 // Output
15 mprintf('No. of total modes propagating in a
   multimode step index fibre = %d',N);
16 //
   ================================================================================
```

Scilab code Exa 3.a.5 Calculating No of Modes

```
1 // Chapter 3 Additional Example 5
2 //
   ================================================================================
```

```
3  clc;
4  clear;
5
6  //input data
7  NA       = 0.25;       // Numerical aperture
8  d        = 6*10^-6    // core diameter
9  lamda    = 1.5*10^-6; // wavelength of laser source
10 n1       = 1.47;       // refractive index of core
11 n2       = 1.43        // refractive index of cladding
12
13 // calculations
14 NA       = sqrt( n1^2 - n2^2);        // Numerical
      Aperture
15 N        = 4.9*(d*NA/lamda)^2;        // no of modes
      for step index fibre
16
17 // Output
18 mprintf('No. of total modes propagating in the fibre
       = %d',N);
19 //
```

Scilab code Exa 3.1 Finding Numerical Aperture

```
1  // Chapter 3 Example 1
2  //
```

```
3  clc;
4  clear;
5
6  //input data
7  n1       = 1.6;       // Refractive index of core
8  n2       = 1.5;       // Refractive index of cladding
```

```
9
10 // Calculations
11 NA      = sqrt(n1^2 - n2^2);         // Numerical
      Aperture of optical fiber
12
13 // Output
14 mprintf('Numerical Aperture of the optical fiber =
      %3.4f',NA);
15 //
```

Scilab code Exa 3.2 Finding Numerical Aperture and Acceptance angle

```
1 // Chapter 3 Example 2
2 //
```

```
3 clc;
4 clear;
5
6 //input data
7 n1      = 1.55;       // Refractive index of core
8 n2      = 1.5;        // Refractive index of cladding
9
10 // Calculations
11 NA      = sqrt(n1^2 - n2^2);         // Numerical
      Aperture of optical fiber
12 im      = asin(NA);                  // Acceptance
      angle
13 im_d    = im*180/%pi                 // radian to
      degree conversion
14
15 // Output
16 mprintf('Numerical Aperture of the optical fiber =
```

```
    %3.4f\n Acceptance angle = %3.2f degrees ',NA,
    im_d);
17 //
```

Scilab code Exa 3.3 Calculating Refractive Index of Cladding

```
1 // Chapter 3 Example 3
2 //
```

```
3 clc;
4 clear;
5
6 //input data
7 NA      = 0.26;       // Numerical aperture
8 n1      = 1.5 ;       // Refractive index of core
9 d       = 100*10^-6; // diameter of the core in m
10
11 // Calculations
12 n2      = sqrt( n1^2 - NA^2);        // Refractive
    index of cladding
13
14 // Output
15 mprintf('Refractive index of cladding = %3.4f',n2);
16 //
```

Scilab code Exa 3.4 Finding Numerical Aperture

```
1 // Chapter 3 Example 4
```

```
2 //
    ================================================================

3 clc;
4 clear;
5
6 //input data
7 n1       = 1.54;       // Refractive index of core
8 n2       = 1.5;       // Refractive index of cladding
9
10 // Calculations
11 NA       = sqrt(n1^2 - n2^2);         // Numerical
    Aperture of optical fiber
12
13 // Output
14 mprintf('Numerical Aperture of the optical fiber =
    %3.4f',NA);
15 //
    ================================================================
```

Chapter 4

Quantum Physics

Scilab code Exa 4.a.1 Finding no of photons emitted

```
1 // Chapter 4 Addutional Example 1
2 //
  ================================================================================

3 clc;
4 clear;
5
6 // input data
7 h        = 6.625*10^-34       // plancks constant
8 c        = 3*10^8;            // vel. of light
9 lamda    = 5893*10^-10;       // wavelength in m
10 P       = 100                // power of sodium
     vapour lamp
11
12 // Calculations
13 E       = (h*c)/lamda;       // Energy in joules
14 N       =  P/E               // Number of photons
     emitted
15
16 // Output
17 mprintf('Number of Photons emitted = %3.4e per
```

```
    second',N);
18 //
```

Scilab code Exa 4.a.2 Finding wavelength of incident beam

```
1  // Chapter 4 AdditionalExample 2
2  //
3  clc;
4  clear;
5
6  // input data
7
8  lamda1  = 0.022*10^-10;       // wavelength of
       scatterd X-rays in m
9  theta   = 45;                 // scatterring angle in
       degrees
10 h       = 6.625*10^-34        // plancks constant
11 mo      = 9.11*10^-31        // mass in Kg
12 c       = 3*10^8;             // vel. of light
13
14 // Calculatioms
15 // from Compton theory ,Compton shift is given by
16 // lamda' - lamda = (h/(mo*c))*(1-cos )
17
18 theta_r = theta*%pi/180;      // degree to radian
       conversion
19 lamda  = lamda1-( (h/(mo*c))*(1-cos(theta_r))) //
       incident Wavelength
20
21 // Output
22 mprintf('Wavelength of incident beam = %3.4f    ',
```

```
    lamda*10^10);
23 //
```

Scilab code Exa 4.a.3 Finding Energy of scattered photon

```
1  // Chapter 4 Additional Example 3
2  //
3  clc;
4  clear;
5
6  // input data
7  Ei      = 1.02*10^6          // photon energy in eV
8  theta   = 90;                // scattered angle in
       degrees
9  h       = 6.625*10^-34       // plancks constant
10 mo      = 9.1*10^-31         // mass of electron in Kg
11 e       = 1.6*10^-19         // charge of electron
12 c       = 3*10^8;            // vel. of light in m/s
13
14 // Calculatioms
15 // from Compton theory ,Compton shift is given by
16 // lamda' - lamda = (h/(mo*c))*(1-cos )
17 theta_r = theta*%pi/180;     // degree to radian
       conversion
18 c_lamda = ( (h/(mo*c))*(1-cos(theta_r))) // Change
       in wavelength in m
19 dv      = c/c_lamda;         // change in frequency
       of the scattered photon
20 dE      = (h*dv)/e           // change in energy of
       scattered photon in eV
21 // This change in energy is transferred as the KE of
```

```
    the recoil electron
Er      = dE;                   // Energy of recoil
    electron
Es      = Ei - Er               // Energy of scattered
    photon


// Output
mprintf('Energy of the recoil electron = %3.4f MeV\n
    Energy of the Scattered photon = %3.4f MeV',Er
    *10^-6,Es*10^-6);
//
```

Scilab code Exa 4.a.4 Finding wavelength of Scattered X rays

```
// Chapter 4 Additional Example 4
//


clc;
clear;

// input data

lamda   = 0.124*10^-10;      // wavelength of X-rays
    in m
theta   = 180;                // Scattering angle in
    degrees
h       = 6.625*10^-34       // plancks constant
mo      = 9.11*10^-31       // mass in Kg
c       = 3*10^8;            // vel. of light

// Calculatioms
```

```
15 // from Compton theory ,Compton shift is given by
16 // lamda' - lamda = (h/(mo*c))*(1-cos )
17
18 theta_r = theta*%pi/180;      // degree to radian
      conversion
19 lamda1  = lamda+( (h/(mo*c))*(1-cos(theta_r))) //
      wavelength of scattered X-rays
20
21 // Output
22 mprintf('Wavelength of Scattered X-rays = %3.4f    ',
      lamda1*10^10);
23 //
```

Scilab code Exa 4.a.5 Finding de Broglie wavelength

```
1 // Chapter 4 Additional Example 5
2 //
```

```
3 clc;
4 clear;
5
6 // input data
7 h        = 6.625*10^-34        // plancks constant
8 m        = 9.11*10^-31         // mass of electron in
      Kg
9 e        = 1.6*10^-19          // charge of electron
10 V       = 2000;                // potential in volts
11
12 // Calculations
13
14 lamda    = h/(sqrt(2*m*e*V))   // de Broglie
      wavelength
```

```
15
16 // Output
17 mprintf('The de-Broglie wavelength of electron = %3
      .4f    ',lamda*10^10);
18 //
```

Scilab code Exa 4.a.6 Finding de Broglie Wavelength

```
1 // Chapter 4 Additional Example 6
2 //

3 clc;
4 clear;
5
6 // input data
7 h        = 6.625*10^-34        // plancks constant
8 m        = 1.678*10^-27        // mass of proton in Kg
9 e        = 1.6*10^-19          // charge of electron
10 Kb      = 1.38*10^-23;        // boltzmann constant
11 T       = 300                 // Temperature in
      kelvin
12 // Calculations
13
14 lamda   = h/(sqrt(3*m*Kb*T))  // de Broglie
      wavelength
15
16 // Output
17 mprintf('The de-Broglie wavelength = %3.4f    ',lamda
      *10^10);
18 //
```

Scilab code Exa 4.a.7 Finding Energy of electron

```
1 // Chapter 4 Additional Example 7
2 //
   ================================================================================

3 clc;
4 clear;
5 // input data
6 h        = 6.625*10^-34        // plancks constant
7 m        = 9.11*10^-31         // mass of electron in
     Kg
8 lamda    = 3*10^-2;              // wavelength of
     electron wave
9 e        = 1.6*10^-19;           // charge of electron
10 // Calculations
11
12 E       = (h^2)/(2*m*lamda^2);  // Energy in Joules
13 E1      = E/e;
14 // Output
15 mprintf('Energy of the electron E = %3.4e eV\n',E1);
16 mprintf(' Note: Calculation mistake in textbook')
17 //
   ================================================================================
```

Scilab code Exa 4.a.8 Proving de Broglie is equal to compton wavelength

```
1 // Chapter 4 Additional Example 8
2 //
   ================================================================================
```

```
clc;
clear;
// input data
h        = 6.625*10^-34          // plancks constant
m        = 9.11*10^-31           // mass of electron in
   Kg
c        = 3*10^8;               // velocity of light in
    m/s

// Calculations
ve       = 0.7071*c              // velocity of electron
lamda    = h/(m*ve*sqrt(1-(ve/c)^2))    // de Broglie
    wavelength

// we know Compton wavelength  ,lamda' - lamda = (h
   /(mo*c))*(1-cos )
// maximum shift     = 180
theta    = 180
theta1   = theta*%pi/180;
d_lamda  = (h/(m*c))*(1-cos(theta1))
mprintf('de Broglie wavelength = %e m\n',lamda);
mprintf(' compton wavelength    = %e m\n',d_lamda)
mprintf(' The de-Broglie wacelength is equal to the
   compton wavelength');
//
```

Scilab code Exa 4.a.9 Finding Eigen Values

```
// Chapter 4 Additional Example 9
//


clc;
```

```
4  clear;
5
6  // input data
7  l       = 10^-10;              // side of one
       dimensional box
8  h       = 6.625*10^-34         // plancks constant in
       Jsec
9  m       = 9.11*10^-31          // mass of electron in
       Kg
10 n1      = 1;                   // for 1st eigen value
11 n2      = 2;                   // for 2nd eigen value
12 n3      = 3;                   // for 3rd eigen value
13 n4      = 4;                   // for 4th eigen value
14 e       = 1.6*10^-19           // charge of electron
       in columbs
15
16 // Calculations
17 E1      = (h^2 * n1^2)/(8*m*l^2 *e ) // first Eigen
       value
18 E2      = (h^2 * n2^2)/(8*m*l^2 *e ) // second Eigen
        value
19 E3      = (h^2 * n3^2)/(8*m*l^2 *e ) // third Eigen
       value
20 E4      = (h^2 * n4^2)/(8*m*l^2 *e ) // fourth Eigen
        value
21
22 // Output
23 mprintf('1st Eigen value  = %3.1f eV\n 2nd Eigen
       value  = %3.1f eV\n 3rd Eigen value  = %3.1f eV\n
        4th Eigen value  = %3.1f eV\n',E1,E2,E3,E4);
24 //
```

Scilab code Exa 4.a.10 Finding Energy of system having two electrons

```
// Chapter 4 Additional Example 10
//
================================================================================

clc;
clear;

// input data
l       = 10^-10    ;           // length of one
    dimensional box in m
h       = 6.625*10^-34          // plancks constant in
    Jsec
m       = 9.11*10^-31           // mass of electron in
    Kg
n       = 1;                    // for ground state
e       = 1.6*10^-19            // charge of electron
    in columbs

// Calculations
E       = 2*(h^2 * n^2)/(8*m*l^2 *e ) // Energy of
    system having two electrons
// Output
mprintf('Energy of the system having two electrons =
    %3.4f eV',E);
//
================================================================================
```

Scilab code Exa 4.a.11 Finding Magnifying power

```
// Chapter 4 Additional Example 10
//
================================================================================

clc;
```

```
4  clear;
5
6  // input data
7  b        = 40;        // angle subtended by final
       images at eye in degrees
8  a        = 10         // angle subtended by the object
        at the eye kept at near point in degrees
9
10 // Calculations
11 b_r      = b*%pi/180;     // degree to radian
       conversion
12 a_r      = a*%pi/180;     // degree to radian
       conversion
13 M        = tan(b_r)/tan(a_r);     // magnifying power
14
15 // Output
16 mprintf('Magnifying power = %3.3f',M);
17 //
```

Scilab code Exa 4.1 Finding Wavelength of the Scattered photons

```
1  // Chapter 4 Example 1
2  //
3  clc;
4  clear;
5
6  // input data
7
8  lamda    = 3*10^-10;          // wavelength of
       incident photons in m
9  theta    = 60;                // viewing angle in
```

```
    degrees
10 h        = 6.625*10^-34       // plancks constant
11 mo       = 9.11*10^-31       // mass in Kg
12 c        = 3*10^8;            // vel. of light
13
14 // Calculatioms
15 // from Compton theory ,Compton shift is given by
16 // lamda' - lamda = (h/(mo*c))*(1-cos )
17
18 theta_r = theta*%pi/180;     // degree to radian
    conversion
19 lamda1  = lamda+( (h/(mo*c))*(1-cos(theta_r))) //
    wavelength of scattered photons
20
21 // Output
22 mprintf('Wavelength of Scattered photons = %3.4f    '
    ,lamda1*10^10);
23 //
```

Scilab code Exa 4.2 Finding Change in Wavelength

```
1 // Chapter 4 Example 2
2 //
```

```
3 clc;
4 clear;
5
6 // input data
7 theta    = 135;               // angle in degrees
8 h        = 6.625*10^-34       // plancks constant
9 mo       = 9.1*10^-31        // mass in Kg
10 c       = 3*10^8;           // vel. of light in m/s
```

```
11
12 // Calculatioms
13 // from Compton theory ,Compton shift is given by
14 // lamda' - lamda = (h/(mo*c))*(1-cos )
15 theta_r = theta*%pi/180;      // degree to radian
      conversion
16 c_lamda = ( (h/(mo*c))*(1-cos(theta_r))) // Change
      in wavelength in m
17
18 // Output
19 mprintf('Change in Wavelength  = %3.5f    ',c_lamda
      *10^10);
20 //
```

Scilab code Exa 4.3 Finding wavelength of Scattered beam

```
1 // Chapter 4 Example 3
2 //
```

```
3 clc;
4 clear;
5
6 // input data
7
8 lamda    = 0.1*10^-9;          // wavelength of X-rays
      in m
9 theta    = 90;                 // angle with incident
      beam in degrees
10 h       = 6.625*10^-34        // plancks constant
11 mo      = 9.11*10^-31        // mass in Kg
12 c       = 3*10^8;             // vel. of light
13
```

```
14 // Calculatioms
15 // from Compton theory ,Compton shift is given by
16 // lamda' - lamda = (h/(mo*c))*(1-cos )
17 theta_r = theta*%pi/180;      // degree to radian
      conversion
18 lamda1  = lamda+( (h/(mo*c))*(1-cos(theta_r))) //
      wavelength of scattered beam
19
20 // Output
21 mprintf('Wavelength of Scattered beam = %3.4f    ',
      lamda1*10^10);
22 //
```

Scilab code Exa 4.4 Finding De Broglie wavelength

```
1 // Chapter 4 Example 4
2 //
3 clc;
4 clear;
5
6 // input data
7 h        = 6.625*10^-34        // plancks constant
8 m        = 9.11*10^-31         // mass of electron in
      Kg
9 e        = 1.6*10^-19          // charge of electron
10 V       = 150;                // potential difference
       in volts
11
12 // Calculations
13
14 lamda    = h/(sqrt(2*m*e*V))   // de Broglie
```

```
    wavelength
15
16 // Output
17 mprintf('The de-Broglie wavelength = %d    ',lamda
    *10^10);
18 //
```

Scilab code Exa 4.5 Finding de Broglie wavelength

```
1 // Chapter 4 Example 5
2 //

3 clc;
4 clear;
5
6 // input data
7 h        = 6.625*10^-34        // plancks constant
8 m        = 9.11*10^-31         // mass of electron in
    Kg
9 e        = 1.6*10^-19          // charge of electron
10 V       = 5000;                // potential in volts
11
12 // Calculations
13
14 lamda    = h/(sqrt(2*m*e*V))   // de Broglie
    wavelength
15
16 // Output
17 mprintf('The de-Broglie wavelength of electron = %3
    .5f    ',lamda*10^10);
18 //
```

Scilab code Exa 4.6 Finding de Broglie wavelength

```
1 // Chapter 4 Example 6
2 //
3 clc;
4 clear;
5
6 // input data
7 E       = 100                  // Energy of electron
     in eV
8 h       = 6.625*10^-34         // plancks constant
9 m       = 9.11*10^-31          // mass of electron in
     Kg
10 e       = 1.6*10^-19           // Charge of electron
     in Columbs
11
12 // Calculations
13
14 E1      = E*e                 // Energy conversion
     from eV to Joule
15 lamda   = h/(sqrt(2*m*E1))   // de Broglie wavelength
16
17 // Output
18 mprintf('The de-Broglie wavelength  = %3.3f    ',
     lamda*10^10);
19 //
```

Scilab code Exa 4.7 Finding de Broglie Wavelength

```
1 // Chapter 4 Example 7
2 //
   ================================================================================

3 clc;
4 clear;
5
6 // input data
7 m        = 1.675*10^-27;      // Mass of proton in kg
8 c        = 3*10^8;            // velocity of light in
     m/s
9 h        = 6.625*10^-34       // plancks constant
10
11 // Calculations
12
13 vp       = c/20;              // velocity of proton in
      m/s
14 lamda    = h/(m*vp)           // de-Broglie wavelength
      in m
15
16 // Output
17 mprintf('de-Broglie wavelength = %e m',lamda);
18 //
   ================================================================================
```

Scilab code Exa 4.8 Finding de Broglie Wavelength of neutron

```
1 // Chapter 4 Example 8
2 //
   ================================================================================

3 clc;
```

```
4  clear;
5
6  // input data
7  E        = 10000                 // Energy of neutron in
       eV
8  h        = 6.625*10^-34          // plancks constant
9  m        = 1.675*10^-27          // mass of neutron in
       Kg
10 e        = 1.6*10^-19
11 // Calculations
12
13 E1       = E*e                   // Energy conversion
       from eV to Joule
14 lamda    = h/(sqrt(2*m*E1))      // de Broglie wavelength
15
16 // Output
17 mprintf('The de-Broglie wavelength of neutron = %3.3
       e m',lamda);
18 //
```

Scilab code Exa 4.10 Finding Energy level and Temperature of molecules

```
1  // Chapter 4 Example 10
2  //
3  clc;
4  clear;
5
6  // input data
7  l        = 0.1*10^-9;            // side of cubical box
8  h        = 6.625*10^-34          // plancks constant in
       Jsec
```

```
9  m        = 9.11*10^-31          // mass of electron in
       Kg
10 Kb       = 1.38*10^-23         // Boltzmann constant
11
12 // Calculations
13 // for cubical box the energy eigen value is Enx ny
       nz = (h^2/(8*m*l^2))*(nx^2 + ny^2 +nz^2)
14 // For the next energy level to the lowest energy
       level nx = 1 , ny = 1 and nz = 2
15 nx       = 1
16 ny       = 1
17 nz       = 2
18 E112     = (h^2/(8*m*l^2))*( nx^2 + ny^2 + nz^2);
19
20 // we know the average energy of molecules of
       aperfect gas = (3/2)*(Kb*T)
21 T        = (2*E112)/(3*Kb);       // Temperature in
       kelvin
22
23 // Output
24 mprintf('E112 = %3.4e Joules\n Temperature of the
       molecules T = %3.4e K',E112,T);
25 //
```

Scilab code Exa 4.11 Finding Minimum energy of an electron

```
1 // Chapter 4 Example 11
2 //


3 clc;
4 clear;
5
```

```
6 // input data
7 l       = 4*10^-9;            // width of infinitely
    deep potential
8 h       = 6.625*10^-34        // plancks constant in
    Jsec
9 m       = 9.11*10^-31         // mass of electron in
    Kg
10 n      = 1;                  // minimum energy
11 e      = 1.6*10^-19          // charge of electron
    in columbs
12
13 // Calculations
14 E      = (h^2 * n^2)/(8*m*l^2)    // Energy of
    electron in an infinitely deep potential well
15 E1     = E/e                      // energy
    conversion from joules to eV
16
17 // Output
18 mprintf('Minimum energy of an electron = %3.4f eV',
    E1);
19 //
```

Scilab code Exa 4.12 Finding Energy for Exciting a electron

```
1 // Chapter 4 Example 12
2 //
```

```
3 clc;
4 clear;
5
6 // input data
7 l       = 0.1*10^-9;          // length of one
```

```
    dimensional box
h       = 6.625*10^-34          // plancks constant in
    Jsec
m       = 9.11*10^-31           // mass of electron in
    Kg
n       = 1;                    // for ground state
n5      = 6;                    // n value for fifth
    excited state
e       = 1.6*10^-19            // charge of electron
    in columbs

// Calculations
Eg      = (h^2 * n^2)/(8*m*l^2 *e ) // Energy in
    ground state in eV
Ee      = (h^2 * n5^2)/(8*m*l^2 * e) // Energy in
    excited state  in eV
E       = Ee - Eg;                  // energy req
    to excite electrons from ground state to fift
    excited state

// Output
mprintf('Energy required to excite an electron from
    ground state to fifth excited state = %3.2f eV',E
    );
//
```

Scilab code Exa 4.13 Finding Energy of electron

```
// Chapter 4 Example 13
//


clc;
```

```
4 clear;
5
6 // input data
7 l       = 0.1*10^-9;          // length of one
    dimensional box
8 h       = 6.625*10^-34        // plancks constant in
    Jsec
9 m       = 9.11*10^-31         // mass of electron in
    Kg
10 n      = 1;                  // for ground state
11 e      = 1.6*10^-19          // charge of electron
    in columbs
12
13 // Calculations
14 E      = (h^2 * n^2)/(8*m*l^2 *e ) // Energy of
    electron in eV
15 // Output
16 mprintf('Energy of an electron = %3.3f eV',E);
17 //
```

Scilab code Exa 4.14 Finding Least energy of electron

```
1 // Chapter 4 Example 14
2 //
3 clc;
4 clear;
5
6 // input data
7 l       = 0.5*10^-9;          // width of one
    dimensional box in m
8 h       = 6.625*10^-34        // plancks constant in
```

```
    Jsec
m       = 9.11*10^-31          // mass of electron in
    Kg
n       = 1;                   // for ground state
e       = 1.6*10^-19           // charge of electron
    in columbs

// Calculations
E       = (h^2 * n^2)/(8*m*l^2 *e ) // Energy of
    electron in eV
// Output
mprintf('Least Energy of an electron = %3.4f eV',E);
//
```

Chapter 5

Crystal Physics

Scilab code Exa 5.a.1 Finding atomic radius

```
1 // Chapter 5 additional Example 1
2 //
   ================================================================================


3 clc;
4 clear;
5
6 // input data
7 // Copper has FCC structure
8 a   = 3.6;       // lattice parameter of copper in
9
10 // Calculations
11
12 r   = a*sqrt(2)/4;       // atomic radius of copper
13
14 // Output
15 mprintf('Atomic Radius of copper = %3.3f    ',r);
16 //
   ================================================================================
```

Scilab code Exa 5.a.2 Finding density of copper

```
1 // Chapter 5 additional Example 2
2 //
  ================================================================================

3 clc;
4 clear;
5
6 // input data
7 // Copper has FCC structure
8
9 r        = 1.278;              // Atomic radius in
    angstrom
10 N       = 6.023*10^26;        // Avagadros number in
    atoms/kilomole
11 A       = 63.54;              // Atomic weight of
    copper
12 n       = 4;                  // No. of atoms per unit
     cell for FCC
13
14 //Calculations
15 r1      = r*10^-10;             // Radius conversion
    from angstrom to m
16 a       = (4*r1)/sqrt(2);       // lattice parameter
    for FCC
17 p       = (n*A)/(N*a^3);        // Density of copper
18
19 //Output
20
21 mprintf(' Density of copper = %3.2f kg/m^3',p);
22 //
  ================================================================================
```

Scilab code Exa 5.a.3 Finding distance between adjacent atoms

```
1 // Chapter 5 additional Example 3
2 //
   ================================================================================

3 clc;
4 clear;
5
6 // input data
7 // NaCl has FCC structure
8
9 ANa      = 23;                  // atomic wt of sodiim
10 ACl     = 35.45                // atomic wt of chlorine
11 N       = 6.023*10^26;         // Avagadros number in
      atoms/kilomole
12 n       = 4                    // No. of atoms per unit
       cell for FCC
13 p       = 2180;                // density in kg/m^-3
14
15 // Calculations
16
17 // p     = (n*A)/(N*a^3);      density
18 A       = ANa+ACl;                 // atomic wt of NaCl
19 a       = ((n*A)/(N*p))^(1/3);     // lattice constant
20 r       = a/2                      // Distance b/w two
      adjacent atoms
21 //Output
22 mprintf('Distance between two adjacent atoms is r =
      %3.2e m',r);
23 //
   ================================================================================
```

Scilab code Exa 5.a.4 Calculating atomic radius of Fe

```
1 // Chapter 5 additional Example 4
2 //
  ================================================================

3 clc;
4 clear;
5
6 // input data
7 // iron has BCC structure
8
9 r        = 1.273;              // Atomic radius in
    angstrom
10 N       = 6.023*10^26;        // Avagadros number in
    atoms/kilomole
11 A       = 55.85       ;       // Atomic weight of Fe
12 n       = 2;                  // No. of atoms per unit
     cell for BCC
13 p       = 7860;               // density in kg/m^-3
14
15 //Calculations
16
17 // p     = (n*A)/(N*a^3);     density
18
19 a       = ((n*A)/(N*p))^(1/3);  // lattice constant
20 a1      = a*10^10;              // m to angstrom
    conversion
21 r       = (a1*sqrt(3))/4         // atomic radius
    for BCC
22
23 //Output
24 mprintf('The Radius of the Fe = %3.3f    ',r);
25 //
```

Scilab code Exa 5.a.5 calculating lattice constant

```
1 // Chapter 5 additional Example 5
2 //
3 clc;
4 clear;
5
6 // input data
7 // KBr has FCC structure
8
9 N        = 6.023*10^26;        // Avagadros number in
    atoms/kilomole
10 A        = 119;                // Atomic weight of
    pottasium bromide
11 n        = 4;                  // No. of atoms per unit
     cell for FCC
12 p        = 2700;               // density in kg/m^-3
13
14 //Calculations
15
16 // p     = (n*A)/(N*a^3);      density
17
18 a        = ((n*A)/(N*p))^(1/3);  // lattice constant
19 a1       = a*10^10;              // m to angstrom
    conversion
20
21 //Output
22 mprintf('Lattice constant = %3.1f    ',a1);
23 //
```

Scilab code Exa 5.a.6 Calculating No of atoms per unit cell

```
1 // Chapter 5 additional Example 6
2 //
  ================================================================================

3 clc;
4 clear;
5 // input data
6 a        = 4.3*10^-10;       // Lattice constant in
7 p        = 960;              // Density of crystal in
    kg/m^3
8 A        = 23;                 // Atomic wt
9 N        = 6.023*10^26;        // avogadros no in atoms
    /kilomole
10
11 //Calculations
12
13 n        = (p*N*(a^3))/A;       // No. of atoms per
    unit cell
14
15 // Output
16 mprintf('No. of atoms per unit cell = %3.0f (BCC)',n
    );
17 //
  ================================================================================
```

Scilab code Exa 5.a.7 Finding Volume of unit cell

```
1 // Chapter 5 additional Example 7
```

```
2 //
   ================================================================

3 clc;
4 clear;
5 // input data
6 // given crystal has BCC structure
7 r    = 1.2*10^-10;        // atomic radius in m
8
9 // Calculations
10
11 a    = (4*r)/sqrt(3);     // lattice constant
12 V    = a^3;               // volume of cell
13
14 //Output
15 mprintf('Volume of the cell = %3.3e m^3',V);
16 //
   ================================================================
```

Scilab code Exa 5.a.8 Finding planar atomic density

```
1 // Chapter 5 additional Example 8
2 //
   ================================================================

3 clc;
4 clear;
5 // input data
6 a    = 4*10^-10;      // lattice constant of the
     crystal
7 h    = 1              // miller indice
8 k    = 0              // miller indice
9 l    = 0              // miller indice
10
```

```
11 //Calculations
12
13 // in fig consider (100) plane. the no of atoms in
      plane ABCD
14 N    = 4*(1/4);        // Number of atoms
15 p    = N/(a*a);        // planar atomic density in
      atoms/m^2
16 p1   = p*10^-6         // planar atomic density in
      atoms/mm^2
17
18 //Output
19 mprintf('planar atomic density = %3.2e atoms/mm^2',
      p1);
20 //
```

Scilab code Exa 5.a.9 Finding miller indices of planes

```
1 // Chapter 5 additional Example 9
2 //


3 clc;
4 clear;
5 // input data
6 // in fig 5(b) the given plane is parallel to X and
      Z axes.Thus,its numerical intercepts on these
      axes is infinity
7 //The numerical intercept on y axis is 1/2. Thus the
       numerical intercepts of plane is (    1/2    )
8 mprintf('Miller indices of plane shown in fig 5.(b)
     = (0 2 0)\n');
9 // in fig 5(c) the given plane is parallel to Z axis
      .Thus its numerical intercept on z axis is
```

```
    infinity
10 // The numerical intercept on x axis is 1 and y axis
    is 1/2. this numerical intercepts on plane is (1
    1/2     )
11 mprintf(' Miller indices of plane shown in fig 5.(c)
    = (1 2 0)\n')
12 // in fig 5(d) the given plane is parallel to Z axis
    .Thus its numerical intercept on z axis is
    infinity
13 // The numerical intercept on x axis is 1/2 and y
    axis is 1/2. this numerical intercepts on plane
    is (1/2 1/2     )
14 mprintf(' Miller indices of plane shown in fig 5.(d)
    = (2 2 0)\n')
15 //
```

Scilab code Exa 5.a.11 Calculating interplanar spacing

```
1 // Chapter 5 additional Example 11
2 //


3 clc;
4 clear;
5
6 //input data
7 // (311) plane in simple cubic lattice
8 h       = 3;              // miller indice
9 k       = 1;              // miller indice
10 l       = 1;              // miller indice
11 a       = 2.109*10^-10    // lattice constant in m
12
13 // Calculations
```

```
14 dhkl     = a/sqrt((h^2)+(k^2)+(l^2)); // interplanar
      distance
15
16 // Output
17 mprintf('d = %3.3e m',dhkl);
18 //
```

Scilab code Exa 5.a.12 Finding lattice constant

```
1  // Chapter 5 additional Example 12
2  //

3  clc;
4  clear;
5
6  //input data
7
8  h        = 1;              // miller indice
9  k        = 1;              // miller indice
10 l        = 0;              // miller indice
11 d        = 2.86*10^-10     // interplanar distance in m
12
13 // Calculations
14 a        = d*sqrt((h^2)+(k^2)+(l^2)); // interplanar
      distance
15
16 // Output
17 mprintf('Lattice constant a = %3.3e m',a);
18 //
```

Scilab code Exa 5.a.13 Proof

```
1 // Chapter 5 Additional Example 13
2 //
   ================================================================================

3 clc;
4 clear;
5
6 h1       = 1;
7 h0       = 0;
8 k0       = 0;
9 l0       = 0;
10 l1      = 1;
11 // calculations
12
13 // we know that dhkl = a/sqrt( h^2 + k^2 + l^2)
14 // let sqrt( h^2 + k^2 + l^2) = p
15 p101     = sqrt( h1^2 + k0^2 + l1^2);
16 p100     = sqrt( h1^2 + k0^2 + l0^2);
17 p001     = sqrt( h0^2 + k0^2 + l1^2);
18
19 // output
20 mprintf('d101 : d100 : d001 :: a/%3.4f : a/%d : a/%d
       ',p101,p100,p001);
21 //
   ================================================================================
```

Scilab code Exa 5.a.14 Finding ratio of intercepts

```
1 // Chapter 5 additional Example 14
```

```
2 //
   ================================================================

3 clc;
4 clear;
5
6 // if a plane cut intercepts of lengths l1,l2,l3 the
     on three crystal axes ,then
7 // l1 : l2 : l3 = pa : pq :rc
8 // where a,b and c are primitive vectors of the unit
     cell and p,q and r are numbers related to miller
     indices (hkl) of plane by relation
9 // 1/p : 1/q : 1/r = h : k : l
10 //since, the crystal is simple cubic a = b = c and
    given that h = 1, k = 1 and l = 1
11 // p : q : r = 1/h : 1/k : 1/l = 1/1 : 1/1 : 1/1
12 // p : q : r = 1 : 1 : 1
13 //similarly l1 : l2 : l3 = 1a : 1a : 1a
14 mprintf('ratio of intercepts on the three axes by
    (111) plane is l1 : l2 : l3 = 1 : 1 : 1');
```

Scilab code Exa 5.a.15 Finding interplanar distance

```
1 // Chapter 5 additional Example 15
2 //
   ================================================================

3 clc;
4 clear;
5
6 //input data
7 r    = 1.246*10^-10;      // atomic radius in m
8 h1   = 1                  // miller indice
9 h2   = 2                  // miller indice
10 k0  = 0                  // miller indice
```

```
11 k1  = 1                    // miller indice
12 k2  = 2                    // miller indice
13 l0  = 0                    // miller indice
14 l1  = 1                    // miller indice
15
16 // Calculations
17 a    = (4*r)/sqrt(2);     // lattice constant
18 d111 = a/sqrt((h1^2)+(k1^2)+(l1^2)); // interplanar
      distance
19 d200 = a/sqrt((h2^2)+(k0^2)+(l0^2)); // interplanar
      distance
20 d220 = a/sqrt((h2^2)+(k2^2)+(l0^2)); // interplanar
      distance
21
22 // Output
23 mprintf('d111 = %3.3e m\n d200 = %3.4e m\n d220 = %3
      .3e m\n',d111,d200,d220');
24 //
```

Scilab code Exa 5.a.16 Finding Miller indices

```
1 // Chapter 5 additional Example 16
2 //

3 clc;
4 clear;
5
6 //input data
7 // the intercept along X-axis be c1 = a
8 // the intercept along Y-axis be c2 = b/2 and
9 // the intercept along Z-axis be c3 = 3c
10 // Therefore, p = c1/a = a/a = 1
```

```
11 // q = c2/b = (b/2)/b = 1/2
12 // r = c3/c = (3c)/c  = 3
13 // therefore h = 1/p = 1
14 // k = 1/q = 2
15 // l = 1/r = 1/3
16 // lcm of 1 1 and 3 = 3
17 h = 1
18 k = 2
19 l = 1/3
20 p = [1 1 3]
21 s = lcm(p);
22 h1= s*h
23 k1= s*k
24 l1= s*l;
25 // Output
26 mprintf('(h k l) = (%d %d %d)',h1,k1,l1);
27 //
```

Scilab code Exa 5.a.17 Calculating Wavelength of X ray

```
1 // Chapter 5 Additional Example 17
2 //


3 clc;
4 clear;
5
6 //input data
7
8 d       = 1.3*10^-10     // interplanar distance
9 n       = 1;             // given first order
10 theta   = 23;            // Bragg reflection angle in
      degrees
```

```
11
12 // Calculations
13 theta1    = theta*%pi/180;    // degree to radian
      conversion
14 // d       = (n*lamda)/(2*sin );     by Braggs law
                  ------------- 1
15 lamda     = (2*d*sin(theta1)/n)
16
17 // Output
18 mprintf('Wavelength of X-ray = %3.4f    ',lamda
      *10^10);
19 //
```

Scilab code Exa 5.1 Finding lattice parameter and Density of copper

```
1 // Chapter 5 Example 1
2 //

3 clc;
4 clear;
5
6 //input data
7 //Copper has FCC structure
8
9 r         = 1.273;              // Atomic radius in
      angstrom
10 N        = 6.023*10^26;        // Avagadros number in
      atoms/kilomole
11 A        = 63.5;               // Atomic weight of
      copper in grams
12 n        = 4;                  // No. of atoms per unit
       cell for FCC
```

```
13
14 //Calculations
15 r1       = r*10^-10;            // Radius conversion
      from angstrom to m
16 a        = (4*r1)/sqrt(2);      // lattice parameter
      for FCC
17 p        = (n*A)/(N*a^3);       // Density of copper
18
19 //Output
20
21 mprintf('Lattice Constant a = %3.1e m\n Density of
      copper = %3.1f kg/m^3',a,p);
```

Scilab code Exa 5.2 Finding Miller indice and interplanar distance

```
1 // Chapter 5 Example 1
2 //
   ================================================================================

3 clc;
4 clear;
5
6 //input data
7 //given intercepts 3,4 and     , the recipocals of
      intercepts is
8 // (1/3):(1/4):(1/    )
9 // LCM = 12
10 // multiplying by LCM we get miller indices
11 // miller indices of a plane are the smallest
      integers of the reciprocals of its intercerpts
12 // therefore miller indices(h k l) is (4 3 0);
13
14 h    = 4;        // miller indice
15 k    = 3;        // miller indice
16 l    = 0;        // miller indice
```

```
17 a    = 2;        // primitive vector of lattice in
   angstrom
18
19 //Calculations
20
21 dhkl     = a/sqrt((h^2)+(k^2)+(l^2)); // interplanar
   distance
22
23 //Output
24 mprintf('Miller indices = (4 3 0)\n');
25 mprintf(' The interplanar distance d = %3.1f    ',
   dhkl);
26 //
```

Scilab code Exa 5.3 Finding Radius of an atom

```
1 // Chapter 5 Example 3
2 //

3 clc;
4 clear;
5
6 //input data
7 //  -Iron solidifies to BCC structure
8
9 r        = 1.273;              // Atomic radius in
   angstrom
10 N       = 6.023*10^26;        // Avagadros number in
   atoms/kilomole
11 A       = 55.85;              // Atomic weight of   -
   Iron in kilograms
12 n       = 2;                  // No. of atoms per unit
```

```
    cell for BCC
p       = 7860;                 // density in kg/m^-3

//Calculations

// p    = (n*A)/(N*a^3);     density

a       = ((n*A)/(N*p))^(1/3);  // lattice constant
a1      = a*10^10;              // m to angstrom
    conversion
r       = (a1*sqrt(3))/4         // atomic radius
    for BCC

//Output
mprintf('The Radius of the atom = %3.5f   \n',r);
mprintf(' Note : atomic wt taken as 55.58*10^-3
    instead of 55.85 in calculation')
//
```

Scilab code Exa 5.4 Calculating interatomic Spacing

```
// Chapter 5 Example 4
//


clc;
clear;

//input data
lamda   = 1.5418;       // wavelength in
h       = 1;            // miller indice
k       = 1;            // miller indice
l       = 1;            // miller indice
```

```
11 n        = 1;              // given first order
12 theta    = 30;             // diffraction angle in
      degrees
13
14 // Calculations
15 theta1    = theta*%pi/180;    // degree to radian
      conversion
16 // d      = (n*lamda)/(2*sin );     by Braggs law
                    ------------- 1
17 // d      = a/sqrt((h^2)+(k^2)+(l^2));  interplanar
      distance    ------------- 2
18 // equating 1 and 2
19
20 a        = (n*lamda*sqrt((h^2)+(k^2)+(l^2))/(2*sin(
      theta1)))
21
22 // Output
23 mprintf('Interatomic spacing a = %f    ',a);
24 //
```

Scilab code Exa 5.5 Finding interplanar distance between planes

```
1 // Chapter 5 Example 5
2 //
3 clc;
4 clear;
5
6 //input data
7 h1        = 1;              // miller indice
8 k1        = 1;              // miller indice
9 l1        = 1;              // miller indice
```

```
10 h0        = 0;              // miller indice
11 k0        = 0;              // miller indice
12 l0        = 0;              // miller indice
13
14 // calculations
15 // dhkl     = a/sqrt((h^2)+(k^2)+(l^2)); //
      interplanar distance
16 // assume a = 1(constant) for easier calculation in
      scilab
17
18 a          = 1;
19 d100       = a/sqrt((h1^2)+(k0^2)+(l0^2)); //
      interplanar distance
20 d110       = a/sqrt((h1^2)+(k1^2)+(l0^2)); //
      interplanar distance
21 d111       = a/sqrt((h1^2)+(k1^2)+(l1^2)); //
      interplanar distance
22
23 // Output
24 mprintf('d100 : d110 : d111 = %d : %3.2f : %3.2f',
      d100,d110,d111);
25
26 //
```

Scilab code Exa 5.6 Finding number of unit cells

```
1 // Chapter 5 Example 6
2 //


3 clc;
4 clear;
5
```

```
6 // input data
7 // Aluminium is FCC
8 a        = 0.405*10^-9;          // lattice constant
     of aluminium
9 t        = 0.005*10^-2;          // thickness of
     aluminium foil in m
10 s       = 25*10^-2;             // side of square in
     m
11
12 //Calculations
13 VUC      = a^3;                  // volume of unit
     cell
14 Val      = (s^2)*t               // volume of
     aluminium foil (area*thickness)
15 N        = Val/VUC               // Number if unit
     cells
16
17 //Output
18 mprintf('Number of unit cells = %3.3e',N);
19 //
```

Scilab code Exa 5.7 Finding percentage change in volume

```
1 // Chapter 5 Example 7
2 //


3 clc;
4 clear;
5
6 // input data
7 // metallic iron changes from  BCC to FCC form at
     910 degress
```

```
8  rb      = 0.1258*10^-9;      // atomic radius of BCC
       iron atom
9  rf      = 0.1292*10^-9;      // atomic radius of FCC
       iron atom
10
11 // Calculations
12
13 ab      = (4*rb)/(sqrt(3));  // lattice constant for
       BCC
14 Vbcc    = (ab^3)/2;          // volume occupied by
       one BCC atom
15 af      = (4*rf)/(sqrt(2))   // lattice constant for
       FCC
16 Vfcc    = (af^3)/4;          // volume occupied by
       one FCC atom
17 dv      = ((Vbcc-Vfcc)/Vbcc)*100        //
       percentage change in volume
18
19 // output
20 mprintf('During the structural change the percentage
       change in volume = %3.4f',dv);
21 //
```

Scilab code Exa 5.8 Finding lattice constant

```
1  // Chapter 5 Example 8
2  //

3  clc;
4  clear;
5
6  //input data
```

```
7 //Copper Crystallines in  FCC structure
8
9 p        = 8960;              // Density of copper in
     kg/m^3
10 N       = 6.023*10^26;       // Avagadros number in
     atoms/kilomole
11 A       = 63.5;              // Atomic weight of
     copper in kg/mol
12 n       = 4;                 // No. of atoms per unit
      cell for FCC
13
14 //Calculations
15
16 a        = ((n*A)/(N*p))^(1/3);
17
18 //Output
19
20 mprintf('Lattice Constant a = %3.4f    \n',a*10^10);
21 mprintf(' atomic wt of copper is taken as 63.5*10^-3
     instead of 63.5 in textbook')
22 //
```

Scilab code Exa 5.9 Calculating d spacing

```
1 // Chapter 5 Example 9
2 //
3 clc;
4 clear;
5
6 //input data
7 // (100) planes in rock crystal
```

```
h        = 1;              // miller indice
k        = 0;              // miller indice
l        = 0;              // miller indice
a        = 2.814           // lattice constant in

// Calculations
dhkl     = a/sqrt((h^2)+(k^2)+(l^2)); // interplanar
   distance

// Output
mprintf('d-spacing for (100) plane in rock salt = %3
   .3f    ',dhkl);
//
```

Scilab code Exa 5.10 Calculating lattice constant

```
// Chapter 5 Example 10
//


clc;
clear;

// input data
// FCC structured crystal

p        = 6250;               // Density of crystal in
    kg/m^3
N        = 6.023*10^26;        // Avagadros number in
   atoms/kilomole
A        = 60.2;               // molecular weight
n        = 4;                  // No. of atoms per unit
    cell for FCC
```

```
13
14 //Calculations
15
16 a        = ((n*A)/(N*p))^(1/3);
17
18 //Output
19
20 mprintf('Lattice Constant a = %3.1e m ',a);
21 //
```

Scilab code Exa 5.11 Calculating interplanar distance

```
1 // Chapter 5 Example 11
2 //

3 clc;
4 clear;
5
6 //input data
7 // (321) plane in simple cubic lattice
8 h        = 3;              // miller indice
9 k        = 2;              // miller indice
10 l       = 1;              // miller indice
11 a       = 4.12            // inter atomic space
12
13 // Calculations
14 dhkl     = a/sqrt((h^2)+(k^2)+(l^2)); // interplanar
   distance
15
16 // Output
17 mprintf('d = %3.2f    ',dhkl);
18 //
```

Scilab code Exa 5.12 Calculating lattice constant of Fe

```
1 // Chapter 5 Example 12
2 //
3 clc;
4 clear;
5
6 // input data
7 // BCC structured crystal
8
9 p        = 7860;              // Density of iron in kg
    /m^3
10 N        = 6.023*10^26;       // Avagadros number in
    atoms/kilomole
11 A        = 55.85;             // Atomic weight
12 n        = 2;                 // No. of atoms per unit
     cell for BCC
13
14 //Calculations
15
16 a        = ((n*A)/(N*p))^(1/3); //lattice constant
17
18 //Output
19
20 mprintf('Lattice Constant of Fe = %3.3f     \n',a
    *10^10);
21 mprintf(' Note: density of iron is taken as 7.86
    instead of 7860 in calculation')
22 //
```

Scilab code Exa 5.14 Finding Volume of Unit cell

```
1 // Chapter 5  Example 14
2 //
   ================================================================================

3 clc;
4 clear;
5
6 // input data
7 r        = 0.123*10^-10;          // Radius of the
     atom
8
9 // Calculations
10 a       = (4*r)/sqrt(3);         // Lattice constant
     in m For a BCC structure
11 V       = a*a*a;                 // Volume of BCC
12
13 // Output
14 mprintf('Volume of the unit cell = %3.4e m^3',V);
15 //
   ================================================================================
```

Scilab code Exa 5.15 Finding Miller indices

```
1 // Chapter 5 Example 15
2 //
   ================================================================================

3 clc;
```

```
clear;

// input data
a   = 0.05;      // unit cell edge of an orthorhombic
    crystal in nm
b   = 0.05;      // unit cell edge of an orthorhombic
    crystal in nm
c   = 0.03;      // unit cell edge of an orthorhombic
    crystal in nm
Ia  = 0.025      // intercept on 'a' in nm
Ib  = 0.02       // intercept on 'b' in nm
Ic  = 0.01       // intercept on 'c' in nm

//Calculations

h   = a/Ia;      // miller indice h
k   = b/Ib;      // miller indice k
l   = c/Ic       // miller indice l

// Output
mprintf('Miller indices (h k l) = (%d %d %d)',h,k,l)
   ;
//
```

Scilab code Exa 5.16 Finding volume of unit cell

```
// Chapter 5 Example 16
//


clc;
clear;
// Magnesium has HCP structure
```

```
// for HCF(Hexagonal closed packed structure)
   consider the relation between 'c' and 'a';
// c/a = sqrt(8/3) = 1.6329
//input data
r    = 0.1605*10^-9;      // radius of magnesium atom
   in m

// Calculations

a    = 2*r                // lattice constant of HCP
c    = a*sqrt(8/3);       // relation b/w c and a in
   HCP
V    = (3*3^0.5)*(a*a*c)/2;       //Volume of unit
   cell in m^3

// Output
mprintf('Volume of the unit cell of magnesium = %3.3
   e m^3',V);
//
```

Scilab code Exa 5.17 Finding interplanar distance

```
// Chapter 5 Example 17
//


clc;
clear;

//input data
// (101),(221) planes in simple cubic lattice
h1        = 1;             // miller indice
k0        = 0;             // miller indice
```

```
10 l1        = 1;              // miller indice
11 h2        = 2;              // miller indice
12 k2        = 2;              // miller indice
13 l1        = 1;              // miller indice
14 a         = 4.2            // inter atomic space
15
16 // Calculations
17 d101     = a/sqrt((h1^2)+(k0^2)+(l1^2)); //
      interplanar distance
18 d221     = a/sqrt((h2^2)+(k2^2)+(l1^2)); //
      interplanar distance
19
20
21 // Output
22 mprintf('d(101) = %3.4f    \n d(221) = %3.1f     ',
      d101,d221);
23 //
```