Scilab Textbook Companion for Concepts Of Modern Physics by A. Beiser[1]

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May 16, 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: Concepts Of Modern Physics

Author: A. Beiser

Publisher: Tata McGraw - Hill Education

Edition: 6

Year: 2006

ISBN: 0-07-049553-X

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

Relativity

Scilab code Exa 1.1 Speed of spaceship relative to Earth

```

t0= 3600; // time interval on Earth, seconds
t= 3601; //time interval for spacecraft as measured from Earth, seconds
c= 2.998 *(10^8); //speed of light, m/s
v=c*sqrt((1-((t0/t)^2))); //relative velocity of spacecraft, m/s
disp(v,"The speed of the Spacecraft relative to Earth (in m/s) is: ")

//Result
//The speed of the Spacecraft relative to Earth (in m/s) is:
//     7064882.
```

Scilab code Exa 1.2 Fine imposed on speeding driver

```

```

```
fg= 5.6*(10^14); //frequency of green color, Hz
fr= 4.8*(10^14); //frequency of red color, Hz
c= 3*(10^8); //velocity of light, m/s
v= c*((fg^2 - fr^2)/(fg^2 + fr^2)); //longitudinal speed of observer, m/s
v= v*3.6; //convert to km/h
R= 1; //rate at which fine is to be imposed per km/h, $
l= 80; //speed limit upto which no fine is to be imposed, km/h
fine= v-l; // fine to be imposed, $
disp(fine,"The fine imposed (in $) is: ")

//Result
// The fine imposed (in $) is:
//   1.652D+08
```

Scilab code Exa 1.3 Red shift in green spectral line

```

v= 6.12*(10^7); //receding velocity with respect to Earth, m/s
c= 3*(10^8); //velocity of light, m/s
L0= 500; //initial wavelength of spectral line, nm
L= L0*sqrt(((1+(v/c))/(1-(v/c)))); //final wavelength of spectral light, nm
Ls= L-L0; //shift in wavelength, nm
disp(Ls,"Shift in Green spectral line (in nm) is: ")

//Result
// Shift in Green spectral line (in nm) is:
//    114.93146
```

Scilab code Exa 1.4 Signals received by Dick and Jane

```

StartingAge= 20; //starting age for both Dick and Jane
c= 3*(10^8); //velocity of light , m/s
v= 0.8*c; //rate of separation of Dick and Jane, m/s
t0= 1; //interval for emission of signals , yr
t1= t0*((1+v/c)/(1-v/c)); //interval for reception of signals on outward journey, yr
t1= t0*(sqrt((1+v/c)/(1-v/c))); //interval for reception of signals on outward journey, yr
t2= t0*(sqrt((1-v/c)/(1+v/c))); //interval for reception of signals on return trip, yr

//Dick's frame of reference
Tout1= 15; //duration of outward trip, yr
Tin1= 15; //duration of return trip, yr
JaneAge= StartingAge+(Tout1/t1)+(Tin1/t2); //Jane's age according to Dick

//Jane's frame of reference
Tout2= 25; //duration of outward trip, yr
d= 20; //delay in transmission of signal to Jane, caused by distance of the star, yr
Tin2= 5; //duration of return trip
DickAge= StartingAge+((Tout2+d)/t1)+(Tin2/t2); //Dick's age according to JAne


disp(JaneAge,"According to Dick, age of Jane(in yr) is:")
disp(DickAge,"According to Jane, age of Dick(in yr) is:")

//Result

// According to Dick, age of Jane(in yr) is:
```

```
//    70.

// According to Jane, age of Dick(in yr) is:
//    50.
```

Scilab code Exa 1.6 Mass of body before explosion

```

mf= 1; //mass of each entity, kg
c= 3*(10^8); //velocity of light, m/s
v= 0.6*c; //velocity of fragments relative to
   original body, m/s
E0= 2*((mf*(c^2))/sqrt(1-((v/c)^2))); //Total energy
    of fragments
m= E0/(c^2); //mass of original body, kg
disp(m,"The total mass of the stationary body (in kg
   ) is: ")

//Result
// The total mass of the stationary body (in kg) is:
//     2.5
```

Scilab code Exa 1.7 Mass of Sun lost in radiation

```

r=1.4; // Rate of arrival of Solar Energy at erath,
   kW per square meter
R=1.5*(10^11); //Radius of Earth, m
pi=22/7; //Mathematical constant

P=r*(4*pi*(R^2)); //Total power recieved by Earth,
   kW
P= P*(10^3); //W
```

```

C= 3*(10^8); //Velocity of light , m/s
E=P; //Energy lost by Sun, J

m= E/(C^2); //Mass of Sun lost per second as energy ,
    kg
disp(m,"Mass lost by sun per second , in Kg, is:")

//Result

// Mass lost by sun per second , in Kg, is:
//    4.400D+09
```

Scilab code Exa 1.8 Total energy for electron and photon

```

c= 3*(10^8); //Velocity of light , m/s
me= 0.511/(c^2); //mass of electron , MeV
mp=0; //mass of proton , MeV
p= 2.000/c; //momenta for both particles , MeV

////Using Eq. 1.24 and 1.25, Page 31
Ee=sqrt(((me^2)*(c^4))+((p^2)*(c^2))); //Total
   energy of electron , MeV
Ep= p*c; //Total energy of proton , MeV

disp(Ee,"Total energy of Electron , in Mev, is: ")
disp(Ep,"Total energy of Photon, in Mev, is: ")

//Results

// Total energy of Electron , in Mev, is:
//   2.0642483

// Total energy of Photon, in Mev, is:
```

```
//      2.
```

Scilab code Exa 1.11 Speed of Spacecraft Beta

```

c=3*(10^8); //velocity of light , m/s
VaE= 0.90*c; //velocity of spacecraft alpha w.r.t
    Earth , m/s
VbA= 0.50*c; //velocity of spacecraft beta w.r.t.
    Alpha , m/s

VbE= (VaE+VbA)/(1+((VaE*VbA)/(c^2))); //velocity of
    beta w.r.t Earth , m/s
VbE=VbE/c; //Converting to percent of c

disp(VbE,"The required velocity of spacecraft Beta w
    .r.t. Earth , in m/s , in terms of percent of c , is
    : ")

//Result

// The required velocity of spacecraft Beta w.r.t.
    Earth , in m/s , in terms of percent of c , is:
//      0.9655172
```

Chapter 2

Particle Properties of Waves

Scilab code Exa 2.1 Energy of Tuning fork and Atomic oscillator

```

Ft= 660; //frequency of tuning fork, Hz
Fo= 5.00*(10^14); //frquency of atomic oscillator,
    Hz
Ef= 0.04; //vibrational energy of tuning fork, J
h= 6.63*(10^(-34)); //Planck's constant, J.s

E1= h*Ft; //Total energy of tuning fork, J
E2= h*Fo; //Total energy of atomic oscillator, J
E2= E2/(1.60*(10^(-19))); //converting to eV

disp(E1,"Energy of tuning fork , in J, is: ")

disp(E2,"Energy of atomic oscillator, in J, is: ")

//Result

// Energy of tuning fork , in J, is:
//     4.376D-31


```

```
//Energy of atomic oscillator , in J, is:
//     2.071875
```

Scilab code Exa 2.2 Photoelectric effect

```

l= 350; //Wavelength of UV light , nm
i= 1.00; //intensity of UV  light , W/m^2

//Part (a)

l= l*10^(-9); //converting to m
Ep= (1.24*(10^(-6)))/l; //energy of photon , using Eqn (2.11) on Page 66, e.V
t= 2.2; //work function of Potassium surface , eV

KEmax= Ep-t //Max KE of the phototelectrons , eV
disp(KEmax,"MAximum KE of photoelectrin , in eV, is: ")

//Part (b)

A= 1.00; //Surface area , cm^2
A= A* 10^(-4); //converting to m^2
E= 5.68*(10^(-19)); //Photon energy , J
Np= i*A/E; //number of incident photon , per second
Ne= (0.0050)*Np; //number of photoeectrons emitted , per second

disp(Ne,"Rate of emission of photoelectrons , per second , is: ")

//Result

// Rate of emission of photoelectrons , per second ,
```

```
is:
//     8.803D+11
```

Scilab code Exa 2.3 Shortest possible x ray wavelength

```

AP= 50000; //Accelerating potential of the x-ray machine, V
l= (1.24*(10^(-6)))/AP*(10^(9));  //Minimum wavelength, nm
disp(l,"Minimum wavelength possible, in nm, is: ")

Fmax= 3*(10^8)/(l*(10^(-9)));  //Maximum frequency, Hz
disp(Fmax,"Maximum frequency possible, in Hz, is: ")


//Result

// Minimum wavelength possible, in nm, is:
//      0.0248

//  Maximum frequency possible, in Hz, is:
//     1.210D+19
```

Scilab code Exa 2.4 X rays

```


//part (a)
l= 10; //wavelength of x-ray, pm
r= 45; //angle of scattered articles, degree
```

```
lc= 2.426*(10^(-12)); //Compton wavelength for electron, m
k= cosd(45);
lc= lc* 10^12; // converting to pm

l2= l+ lc*(1-k) //using Eqn 2.23
disp(l2,"The wavelength of scattered x-ray, in pm, is: ")

//Result
// The wavelength of scattered x-ray, in pm, is:
//    10.710559


//Part (b)

lmax= l+(lc*2); //for (1-k)=2
disp(lmax,"Maximum wavelength, in pm, is: ")

//Result
// Maximum wavelength, in pm, is:
//     14.852

//Part (c)
h= 6.63*(10^(-34)); //Planck's constant, J.s
c= 3*10^8; //velocity of light, m/s
c=c*10^12; //converting to pm/s
KEmax= (h*c)*((1/l)-(1/lmax)); //J
disp(KEmax,"The maximum KE of recoil electrons, in J, is: ")

//Result
// The maximum KE of recoil electrons, in J, is:
//     6.498D-15
```

Scilab code Exa 2.6 Energy of protons

```

//Example 2.6 (b)

c=3*10^8; //velocity of light , m/s
V= 0.5*c; //velocity of electron and positron , m/s
y= 1/sqrt(1-(V/c^2)); //gamma, for relativistic momentum
m=0.511/c^2; //MeV

K= 2*y*m*V; //difference in momentum of both photons
L= 2*y*m*c; //conservation of energy , sum of momentum of both photons

p1= (L+K)/2; //momentum of first photon , MeV
disp(p1*c ,"The momentum of forst photon , in MeV /c , is: ")
disp((1-p1*c) ,"The momentum of second photon , in MeV /c , is: ")

//Result
// The momentum of forst photon , in MeV /c , is:
//     0.7665

// The momentum of second photon , in MeV /c , is:
//    0.2335
```

Scilab code Exa 2.7 Linear attenuation

```

M= 4.9; //Linear attenuation coefficient for gamma ray in water , m^(-1)
I= 2.0; //Original intensity of gamma ray , MeV

```

```
//Part (a)

x= 10; //distance travelled under water, cm
x= x/100; //converting to m
Irel= %e^(-(M*x)); //Relative intensity
disp(Irel,"Relative intensity of the beam is: ")

//Result
// Relative intensity of the beam is:
//  0.6126264

//Part(b)

Ip= I/100; //Present intensity, 1 percent of
    Original, MeV
x2= log(I/Ip)/M; //distance travelled, m
disp(x2,"The distance travelled by the beam is: ")

//Result
// The distance travelled by the beam is:
//  0.9398307
```

Scilab code Exa 2.8 Frequency of falling photon

```

H= 22.5; //Height of fall, m
F= 7.3*(10^14); //Original frequency, Hz
c= 3*(10^8); //velocity of light, m/s
g= 9.8; //Acceleration due to gravity, m/s^2

Frel= g*H*F/(c^2); //Change in frequency, Hz
disp(Frel, "The change in frquency of a photon
    fallin through 22.5 m, in Hz, is: ")

//Result
```

```
// The change in frquency of a photon fallin through
    22.5 m, in Hz, is:
//   1.7885
```

Chapter 3

Wave Properties of Particles

Scilab code Exa 3.1 De Broglie wavelength

```
//Example 3.1 (a)
m= 46; //mass, gms
v=30; //velocity, m/s
h= 6.63*(10^(-34)); //Planck's constant, J.s
m=m/1000; //convert to kgs
a=h/(m*v); //de Broglie wavelength, m
disp(a,"The de Broglie wavelength of the golf ball (
   in m) is:")

//Result
// The de Broglie wavelength of the golf ball (in m)
    is:
//     4.804D-34

//Example 3.1(b)
m= 9.1*(10^(-31)); //mass, kg
v=10^7; //velocity, m/s
h= 6.63*(10^(-34)); //Planck's constant, J.s
a=h/(m*v); //de Broglie wavelength, mts
disp(a,"de Broglie wavelength for the electron (in m
   ) is: ")
```

```
//Result
// de Broglie wavelength for the electron (in m) is:
//    7.286D-11
```

Scilab code Exa 3.2 Kinetic energy

```
a=10^(-15); //de Broglie wavelength, mts
Eo= 0.938; //proton rest energy, GeV
h= 4.136*(10^(-15)); //Planck's constant, eV.s
c= 2.998*(10^8); //velocity of light, m/s
p= h/a; // p is momentum, kg.m/s
pc= (h*c)/a; //Photon's energy, ev
pc=pc*(10^(-9)); //convert to GeV
                 //pc>E0, relativistic calculation
E= sqrt((Eo^2) + (pc^2)); //total energy, GeV
KE = E-Eo; //Kinetic energy, GeV
KE= KE*1000; // convert to MeV
disp(KE,"Kinetic Energy of the proton (in MeV) is: "
   )


//Result
// pc  =
//    1.2399728

// Kinetic Energy of the proton (in MeV) is:
//    616.79148
```

Scilab code Exa 3.3 Kinetic energy and phase and group velocity

```
a= 2*(10^(-12)); //de Broglie wavelength, mts
h= 4.136*(10^(-15)); //Planck's constant, eV.s
c= 3*(10^8); //velocity of light, m/s
pc= (h*c)/a; //p is momentum, pc is electron's energy, eV
pc= pc/1000; //convert to keV
Eo= 511; //rest energy, keV
E= sqrt((Eo^2)+(pc^2)); //Total Energy, keV
KE= E-Eo; //Kinetic energy, keV
disp(KE,"kinetic energy of the electron (in keV) is:")

//Result
// kinetic energy of the electron (in keV) is:
//     292.75193

vg= c*(sqrt(1-(Eo^2/E^2))) //group velocity, m/s
vp= c^2/vg //phase velocity, m/s
disp(vg,"group velocity of the electron (in m/s) is:")
disp(vp,"phase velocity of the electron (in m/s) is:")

//Result
// group velocity of the electron (in m/s) is:
//     2.316D+08

// phase velocity of the electron (in m/s) is:
//     3.887D+08
```

Scilab code Exa 3.4 Permitted energies of electron

```
m= 9.1*(10^(-31)); //mass, kg
L= 0.10; //length of box, nm
L= L*(10^(-9)); //convert to m
h= 6.63*(10^(-34)); //Planck's constant, J.s

for n= 1:5; //for energy levels 1 to 5
En=(n^2)*(h^2)/(8*m*(L^2)); //Permitted energies, J
disp(n,"for level:")
disp(En,"Permitted ernergis (in J) : ")
En=38*(n^2);
disp(En, "Permitted energies (in eV) : ")
end
```

Scilab code Exa 3.5 Permitted energies of marble

```
m= 10; //mass, gms
m= m/1000 //convert to kgs
L= 10; //Length of box, cms
L= L/100 //convert to mts
h= 6.63*(10^(-34)) //Planck's constant, J.s

for n= 1:5; //for energy levels 1 to 5
En=(n^2)*(h^2)/(8*m*(L^2)); //Permitted energies, J
disp(n,"for level:")
disp(En,"Permitted ernergis (in J) : ")
end

//corresponding kinetic energy is very low, hence
   Quantum effects are imperceptible, and Newtonian
   mechanics is dominant
```

Scilab code Exa 3.6 Uncertainty in position

```
Xo= 10^(-11); //uncertainty at time t=o, mts
hb= 1.054*(10^(-34)); //h-bar, reduced Planck's
    constant, J.s
t= 1; //time, s
m= 1.672*(10^(-27)); //mass, kg
x1= hb*t/(2*m*Xo); //uncertainty at time t=1, mts
disp(x1,"accuracy in position of proton after 1.00
    seconds (in m) is : ")

//Result
// accuracy in position of proton after 1.00 seconds
    (in m) is :
//      3151.9139
```

Scilab code Exa 3.7 Minimum energy of electron

```
r= 5*(10^(-15)); //radius of nucleus, mts
Xo= 5*(10^(-15)); //assumed initial uncertainty, mts
hb= 1.054*(10^(-34)); //reduced Planck's constant, J
    .s
p= hb/(2*Xo); //uncertainty in momentum, kg.m/s
disp(p,"Uncertainty in momentum of the electron is :
    ")

c= 3*(10^8); //velocity of light, m/s
KE= p*c; //minimum kinetic energy required, J
KE= KE/(1.6*(10^(-19))); //convert to eV
KE= KE/(10^6); //convert to MeV
disp(KE,"The minimum energy required (in MeV) is : "
    )


//Result
// Uncertainty in momentum of the electron is :
//      1.054D-20
```

```
// The minimum energy required (in MeV) is :
//     19.7625
```

Scilab code Exa 3.8 Minimum energy for electron

```
r= 5.3*(10^(-11)); //radius of atom, mts
Xo= 5.3*(10^(-11)); //uncertainty in position, mts
hb= 1.054*(10^(-34)); //Reduced planck Constant, J.s
p= hb/(2*Xo); //uncertainty in momentum, kg.m/s
m= 9.1*(10^(-31)); //mass, kg
KE= p^2/(2*m); // minimum kinetic energy, J
KE= KE/(1.6*(10^(-19))); //convert to eV
disp(KE,"The minimum possible kinetic energy for an
    electron in the atom (in eV) is : ")


//Result
// The minimum possible kinetic energy for an
    electron in the atom (in eV) is :
//     3.3952997
```

Scilab code Exa 3.9 Uncertainty in frequency

```
t= 10^(-8); //time period between excitation and
    radiation, s
hb= 1.054*(10^(-34)); //Reduced Planck's constant, J
    .s
Eo= hb/(2*t); //uncertainty in photon energy, J
disp(Eo,"Photon energy is uncertain by (in J) :")
h=hb*(2*(%pi)); //Planck's constant
Fo= Eo/h; //uncertainty in frequency of light, Hz
```

```
disp(Fo,"Frquency of photon is uncertain by (in Hz)
   : ")

//Result

// Photon energy is uncertain by (in J) :
//     5.270D-27

// Frquency of photon is uncertain by (in Hz) :
//     7957747.2
```

Chapter 4

Atomic Structure

Scilab code Exa 4.1 Orbital radius and velocity of electron

```

E= -13.6; //Energy required to separate electron and proton, eV
e= 1.6*(10^(-19)); //charge of an electron, C
E= E*e; //converting to J
Po= 8.85*(10^(-12)); //Permittivity of free space, F/m
r= e^2/(8*(%pi)*Po*E); //radius, m
r= -r;
m= 9.1*(10^(-31)); //mass of electron, kg
v=e/sqrt(4*(%pi)*Po*m*r); //velocity, m/s

disp(r,"The orbital radius of the electron, in m, is: ")
disp(v,"The velocity of electron, in m/s, is: ")


//Result
//The orbital radius of the electron, in m, is:
//     5.289D-11

```

```
// The velocity of electron, in m/s, is:
//   2186873.9
```

Scilab code Exa 4.2 Energy transferred in inelastic collision

```

n1=1; //initial state
n2=3; //final state
E= -13.6; //energy in ground state, eV

dE= E*((1/n2^2)-(1/n1^2)); //Change in energy, eV
disp(dE,"The energy change of Hydrogen atom, in eV, is: ")

//Result
// The energy change of Hydrogen atom, in eV, is:
//   12.088889
```

Scilab code Exa 4.3 Rydberg Atom

```

//Part(a)
Rn= 10^(-5); //radius of Rydberg atom, m
Ao= 5.29*(10^(-11)); //Bohr radius, m
n= sqrt(Rn/Ao); //Quantum number

disp(n,"The quantum number of the Rydberg atom is: ")

//Result
//  The quantum number of the Rydberg atom is:
//    434.78261

```

```
//Part (b)
E1= -13.6; //Ground state energy level, eV
En= E1/n^2; //Nth state energy level, eV
disp(En,"The energy ofthe rydberg atom is: ")

//Result
// The energy ofthe rydberg atom is:
// - 0.0000719
```

Scilab code Exa 4.4 Longest wavelength in Balmer series

```

n1= 3; //initial state
n2= 2; //final state
R= 1.097*(10^7); //Rydberg's constant, m^(-1)
k= (1/n2^2)-(1/n1^2);
l= 1/(k*R); //longest wavelength, m
l= l*(10^9); //converting to nm

disp(l,"The longest in Balmer series of Hydrogen, in
    nm, is: ")

//Result
// The longest in Balmer series of Hydrogen, in nm,
   is:
//    656.33546
```

Scilab code Exa 4.5 Revolution of electrons

```

//Part (a)
//Caption: find frequency of revolution of electrons

```

```
n1=1; //initial state
n2=2; //final state
E1= 2.18*(10^(-18)); //Rydberg's constant, J
h= 6.63*(10^(-34)); //Planck's constant, J.s
f1= (E1/h)*(2/n1^3); //Frequency for first orbit, rev/s
f2= (E1/h)*(2/n2^3); //Frequency for second orbit, rev/s
disp(f1,"Frequency of revolution for orbit n=1, in rev/s, is: ")
disp(f2,"Frequency of revolution for orbit n=2, in rev/s, is: ")

//Result
// Frequency of revolution for orbit n=1, in rev/s, is:
//    6.576D+15

// Frequency of revolution for orbit n=2, in rev/s, is:
// 8.220D+14

//Part (b)
//Caption: find frequency of emitted photon

n1=2; //initial orbit
n2=1; //final orbit
f= (E1/h)*((1/n2^2)-(1/n1^2)); //frequency, Hz
disp(f,"Frequency of emitted photon, in Hz, is: ")

//Result
// Frequency of emitted photon, in Hz, is:
//     2.466D+15


//Part (c)
//Caption: find number of revolutions an electron makes in given time
```

```

n= 2; //orbit
f= f2; //from part (a)
dt= 10^(-8); // time duration , s
N= f*dt; //Number of revolutions
disp(N,"Number of revolutions the electron makes is:
    ")

//Result
// Number of revolutions the electron makes is:
//     8220211.2
```

Scilab code Exa 4.7 Muonic atom

```

//Part (a)
Me= 9.1*(10^(-31)); //mass of electron , kg
m= 207*Me; //mass of muon, kg
Mp= 1836*Me; //mass of proton , kg
Mreduced= (m*Mp)/(m+Mp); //reduced mass, kg
Ao= 5.29*(10^(-11)); //Bohr's orbit for n=1, m
r1= Ao; //expected orbit for atom, m
r2= (Me/Mreduced)*r1; //reduced radius of orbit , m

disp(r2,"Radius of the mounic atom formed, in m, is:
    ")

//Result
// Radius of the mounic atom formed, in m, is:
//     2.844D-13

//Part (b)
E=-13.6; // energy for elctron in n=1, eV
Ereduced= (Mreduced/Me)*E; //energy for eectron in
    mounic atom, eV
```

```
Ereduced= Ereduced/(10^3);//converting to keV
disp(Ereduced,"Ionisation energy for the muonic atom
    , in keV, is: ")

//Result
// Ionisation energy for the muonic atom, in keV, is
    :
//  - 2.5299595
```

Scilab code Exa 4.8 Alpha particles

```

I= 7.7; //Intensity of beam, MeV
Dgold= 1.93*(10^4); //density of gold foil used, kg/
    m^3
u= 1.66*(10^(-27)); //atomic mass unit, kg
Mgold= 197*u; //atomic mass of gold, per atom
n= Dgold/Mgold; //number of atoms per unit volume,
    atoms/m^3
Zgold= 79; //atomic number of gold
e= 1.6*(10^(-19)); //electronis charge, C
KE= (I*e)/(10^(-6)); //converting to J
angle= 45; //degree
p=cotd(angle/2);
Po= 8.85*(10^(-12)); //Permittivity of free space, F
    /m
t= 3*(10^(-7)); //thickness of foil, m

f= (%pi)*n*t*(((Zgold*(e^2))/(4*(%pi)*Po*KE))^2)*(p
    ^2) //using Rutherford scattering formula
disp(f,"Fraction of the beam scattered through 45
    degree or more, in percent, is: ")

//Result
// Fraction of the beam scattered through 45 degree
```

```
   or more, in percent, is:
//    0.0000706
```

Chapter 5

Quantum Mechanics

Scilab code Exa 5.4 Positional probability

```

L= 1; //assuming Length L of box to be 1, this would
    not affect the probability
x1=0.45*L; //lower bound
x2=0.55*L; //upper bound

function y=f(x)
y= ((sin(n*(%pi)*x))^2)
endfunction      //defined the function

n=1;
P1= (2/L)*intg(x1,x2,f); //for ground state

n=2;
P2= (2/L)*intg(x1,x2,f);  //for first excited state

disp(P1,"The probability n ground state is: ")
disp(P2,"The probability in first excited state is:
   ")

//Result
```

```
// The probability n ground state is:
//     0.1983632

// The probability in first excited state is:
//     0.0064511
```

Scilab code Exa 5.6 Transmission probability

```

//Part (a)
E1= 1.0; //energy of first electron , eV
E2= 2.0; //energy of second electron , eV
Eb= 10.0; //height of barrier , eV
Wb= 0.50; //width of barrier , nm
Wb= Wb* 10^(-9); //converting to m
hbar= 1.054*(10^(-34)); //reduced Planck's conctaant
    , J.s
Me= 9.1*(10^(-31)); //mass of electron , kg
e= 1.6*(10^(-19)); //charge of an electron , J/eV
k1= sqrt(2*Me*(Eb-E1)*e)/hbar; //for first electron ,
     m^(-1)
k2= sqrt(2*Me*(Eb-E2)*e)/hbar; //for second electron
    , m^(-1)
T1= (%e)^((-2)*k1*Wb) //transmission probability for
     first electron
T2= (%e)^((-2)*k2*Wb) //for second electron
disp(T1,"Transmission probability for electrons with
     energy 1.0 eV is: ")
disp(T2,"Transmission probability for electrons with
     energy 2.0 eV is: ")

//Part (b)
Wb= Wb*2; //Barrier width doubled
T11= (%e)^((-2)*k1*Wb) // changed transmission
    probability for first electron
```

```
T22= (%e)^((-2)*k2*Wb) //for second electron
disp(T11,"Transmission probability for electrons
   with energy 1.0 eV is: ")
disp(T22,"Transmission probability for electrons
   with energy 2.0 eV is: ")
```

Chapter 6

Quantum Theory of the Hydrogen Atom

Scilab code Exa 6.4 Zeeman components

```

B= 0.300; //magnetic field , T
Lambda= 450; //wavelength , nm
Lambda= Lambda*(10^(-9)); //converting to m
e= 1.6*(10^(-19)); //charge of an electron , C
Me= 9.1*(10^(-31)); //mass of electron , kg
c= 3 *(10^8); //speed of light , m/s
dLambda= e*B*(Lambda^2)/(4*(%pi)*Me*c); //m
dLambda= dLambda*(10^9); //converting to nm
disp(dLambda,"The separation between Zeeman
    components is: ")
//Result
// The separation between Zeeman components is:
//     0.0028333
```

Chapter 7

Many Electron Atoms

Scilab code Exa 7.1 Equatorial velocity of electron

```

r= 5*(10^(-17)); //radius of spherical electron, m
Me= 9.1*(10^(-31)); //mass of electron, kg
h= 6.63*(10^(-34)); //Planck's constant, J.s
hbar= h/(2*(%pi)); //reduced Planck's constant, J.s
v= (5*sqrt(3)/4)*(hbar/(Me*r)); //using Eqn 7.1, Page 230
c= 3*(10^8); //velocity of light, m/s
v= v/c; //converting in terms of c, m/s
disp(v,"The velocity of electron in times of c, in m/s, is: ")

//Result
// The velocity of electron in times of c, in m/s, is:
//     16736.77
```

Scilab code Exa 7.2 Effective charge on outer electron

```
n= 2; //outer (2s) orbit of lithium
E2= -5.39; //Ionisation energy of lithium , for n=2 eV
E1= -13.6; //for n=1, eV
Z= n*(sqrt(E2/E1)) //modification factor for effective charge
e= 1.6*(10^(-19)); //charge of an electron , C
Ceffective = Z*e;

disp(Ceffective,"The effective charge , in C, is: ")

//Result
// The effective charge , in C, is:
//    2.015D-19
```

Scilab code Exa 7.3 Magnetic energy for electron

```
n= 2; //for 2p state
Ao= 5.29*(10^(-11)); //Bohr's orbit for n=1, m
r= (n^2)*Ao; //orbital radius , m
f= 8.4*(10^14); //frequency of revolution , Hz ,using Eqn 4.4
Mo= 4*(%pi)*(10^(-7)); //Magnetic constant , T.m/A
e= 1.6*(10^(-19)); //charge of an electron , C
B= (Mo*f*e)/(2*r); //Magnetic field , T
Mb= 9.27*(10^(-24)); //Bohr Magneton, J/T
Um= Mb*B; //Magnetic energy , J
Um= Um/e; //converting to eV
disp(Um,"The magnetic energy for electron , in eV, is : ")

//Result
// The magnetic energy for electron , in eV, is:
```

```
//     0.0000231
```

Scilab code Exa 7.8 X ray lines

```

l= 0.180; //wavelength , nm
l= l* 10^(-9); //converting to m
c= 3*(10^8); //velocity of light , m/s
f= c/l; //frequency , Hz
R= 1.097*(10^7); //Rydberg's constant , per m
Z= 1+(sqrt((4*f)/(3*c*R))); //using Eqn 7.21
disp(Z,"The element has atomic number: ")

//Result
// The element has atomic number:
//    26.985424
```

Chapter 8

Molecules

Scilab code Exa 8.1 Energy and angular velocity

```

//Part (a)
r= 0.113; //bond length, nm
Mc= 1.99*(10^(-26)); //mass of C12, kg
Mo= 2.66*(10^(-26)); //mass of O16, kg
Mco= (Mc*Mo)/(Mc+Mo); //mass of CO, kg
I= Mco*((r*(10^(-9)))^2); //moment of inertia, kg.m^2
J=1; //lowest rotational state
h= 6.63*(10^(-34)); //Planck's constant, J.s
hbar= h/(2*(%pi)); //reduced Planck's constant, J.s
E1= (J*(J+1)*(hbar^2))/(2*I); //energy corresponding to state J=1, J
e= 1.6*(10^(-19)); //charge of an electron, C
E1= E1/e; //converting to eV
disp(E1,"The energy of CO molecule, in eV, is: ")

//Result
// The energy of CO molecule, in eV, is:
//     0.0004787

```

```
//Part(b)
w= sqrt((2*E1*e)/(I)); //angular velocity, rad/s
disp(w,"The angular velocity, in rad.sec, is: ")

//Result
// The angular velocity, in rad.sec, is:
//    1.027D+12
```

Scilab code Exa 8.2 Bond length of CO

```

Ji=0; //initial state
Jf=1; //final state
f= 1.15*(10^11); //frequency for the absorption, Hz
h= 6.63*(10^(-34)); //Planck's constant, J.s
hbar= h/(2*(%pi)); //reduced Planck's constant, J.s
Ico= hbar*Jf/(2*(%pi)*f); //moment of inertia, kg.m
   ^2
Mco= 1.14*(10^(-26)); //Mass of CO, refer Exa 8.1
r= sqrt(Ico/Mco); //bond length, m
r= r*(10^9); //converting to nm
disp(r,"The bond length of CO molecule, in nm, is: "
   )

//Result
// The bond length of CO molecule, in nm, is:
//    0.1131815
```

Scilab code Exa 8.3 Infrared radiation by CO

```
//Part (a)
f= 6.42*(10^13); //frequency of absorbed radiation,
   Hz
```

```
Mco= 1.14*(10^(-26)); //mass of CO, kg
k= 4*((%pi)^2)*(f^2)*Mco; //using Eqn 8.15, Page 287
disp(k,"The forcs constant for the bond in CO molecule, in N/m, is: ")

//Result
// The forcs constant for the bond in CO molecule, in N/m, is:
//     1854.9604

//Part (b)
h= 6.63*(10^(-34)); //Planck's constant, J.s
dE= h*f; //separation, J
disp(dE,"The separation in its vibrational eergy levels, in J, is: ")

//Result
// The separation in its vibrational eergy levels, in J, is:
//     4.256D-20
```

Chapter 9

Statistical Mechanics

Scilab code Exa 9.1 Atoms of hydrogen

```
k= 8.617*10^(-5); //Boltzmann constant, eV/K
To=273; //initial temperature, K
E1= -13.6; //energy of ground state, eV
E2= -3.4; //energy of first excited state, eV
dE= E2-E1; //difference in energy levels
g1=2; //number of energy states for E1
g2=8; //number of energy states for E2

J= dE/(k*To);
Nratio1= (g2/g1)*(%e)^(-J); //ratio of number of
    atoms in level 2 and level 1 at To

T1=10273; //K
J1= J*To/T1;
Nratio2= (g2/g1)*(%e)^(-J1); //at T1

disp(To,"The ration at 273 K is: ")
disp(T1,"The ratio at 10273 k is: ")
```

Scilab code Exa 9.4 RMS speed of oxygen molecule

```

Moxygen= 16.0; //atomic mass,u
Mo2= 32.0; //Molecular mass, u
u= 1.66*(10^(-27)); //atomic mass unit, kg
Moxygen= Mo2*u; //mass, kg
t= 273; //temperature, K
k= 1.38*10^(-23); //Boltzmann constant, J/K
Vrms= sqrt(3*k*t/Moxygen); // m/s
disp(Vrms,"The rms velocity of oxygen is: ")

//Result
// The rms velocity of oxygen is:
//    461.26708
```

Scilab code Exa 9.5 Photons

```

//Part (a)
V= 1.00; //volume, cm^3
V= V*10^(-6); //converting to m^3
dI= 2.404; //standard value of definite Integral
    used
k= 8.617*10^(-5); //Boltzmann constant, eV/K
h= 4.13*(10^(-15)); //Planck's constant, eV.s
T= 1000; //temperature, K
c= 3 *(10^8); //speed of light, m/s
N= 8*(%pi)*V*dI*[(k*T/(h*c))^3];
disp(N,"the number of photons is: ")

//Result
// the number of photons is:
//     2.032D+10

```

```
//Part(b)
Sig= 5.670*10^(-8); //Stefan's constant, W/m^2.K^4 , refer to Page 317
Ephoton= Sig*(c^2)*(h^3)*T/(2.405*(2*(%pi)*(k^3))); //J
disp(Ephoton,"The average energy of the photons, in J, is: ")

//Result
// The average energy of the photons, in J, is:
//    3.718D-20
```

Scilab code Exa 9.6 Energy density of radiation

```

T= 2.7; //blackbody temperature, K
Lambda= 2.898*10^(-3)/T; //using wein's displacement law, Eqn 9.40, m
Lambda= Lambda*10^(3); //converting to mm
disp(Lambda,"The wavelength for maximum radiation, in mm, is: ")

//Result
// The wavelength for maximum radiation, in mm, is:
//    1.0733333
```

Scilab code Exa 9.7 Surface temperature of sun

```

Rearth= 1.5*10^(11); //radius of earth, m
r= 1.4; //rate of arrival of sunlight, kW/m^2
P= (r*10^3)*4*(%pi)*(Rearth^2); //total power reaching Earth
```

```
Rsun= 7*10^(8); //radius of Sun, m
r2= P/(4*(%pi)*(Rsun^2)); //radiation rate of Sun, W/m^2
emissivity=1; //for blackbody
Sig= 5.670*10^(-8); //Stefan's constant, W/m^2.K^4
T= [r2/(emissivity*Sig)]^(1/4);
disp(T,"The surface temperature of Sun, in K, is: ")

//Result
//The surface temperature of Sun, in K, is:
//    5802.7366
```

Scilab code Exa 9.8 Fermi energy in copper

```

u= 1.66*(10^(-27)); //atomic mass unit, kg
density= 8.94*10^(3); // kg/m^3
M= 63.5; //atomic mass of copper, u
Edensity= density/(M*u); //electron density, electrons/m^3
h= 6.63*(10^(-34)); //Planck's constant, J.s
Me= 9.1*(10^(-31)); //mass of electron, kg
Efermi= h^2/(2*Me)*[(3*Edensity)/(8*(%pi))]^(2/3); // J
disp(Efermi,"The fermi energy, in J, is: ")

//Result
//The fermi energy, in J, is:
//    1.130D-18
```

Chapter 10

The Solid State

Scilab code Exa 10.1 Cohesive energy in NaCl

```

Ro= 0.281; //equilibrium distance between ions , nm
alpha= 1.748; //Madelung constant
n= 9; //exponent , from observed compressibilities of
    NaCl
e= 1.6*(10^(-19)); //charge of an electron , C
Po= 8.85*(10^(-12)); //Permittivity of free space , F
   /m
K=1/(4*(%pi)*Po); //constant , N.m^2/C^2
Uo= -(K*alpha*(e^2)*(1-(1/n)))/(Ro*(10^(-9))); //
   Potential energy per ion pair , J
Uo= Uo/e; //converting to eV
E1= 5.14; //Ionisation energy for Na, eV
E2= -3.61; //electron affinity of Cl, eV
E= E1+E2; //Electron transfer energy, eV
Ecohesive = (Uo +E); //per electron pair , eV
Ecohesive= Ecohesive/2; //for each ion , eV
disp(Ecohesive,"The cohesive energy in NaCl, in eV,
   is: ")

//Result
```

```
// The cohesive energy in NaCl, in eV, is:
//  - 3.2125847
```

Scilab code Exa 10.2 Drift velocity

```

A= 1; //cross-sectional area of wire, mm^2
I= 1; //current in wire, A
n= 8.5*(10^28); // electrons/m^3
e= 1.6*(10^(-19)); //charge of an electron, C
Vdrift= I/(n*(A*(10^(-6)))*e); //m/s
disp(Vdrift,"The drift velocity of electrons in the
    copper wire, in m/s, is: ")

//Result
// The drift velocity of electrons in the copper
    wire, in m/s, is:
//     0.0000735
```

Scilab code Exa 10.3 Mean free path

```

n= 8.48*(10^28); //free electron density, m^(-3)
Vfermi= 1.57*(10^6); //Fermi Velocity, m/s
rho= 1.72*(10^(-8)); //resistivity, ohm
e= 1.6*(10^(-19)); //charge of an electron, C
Me= 9.1*(10^(-31)); //mass of electron, kg
lambda= Me*Vfermi/(n*(e^2)*rho); //m
lambda= lambda*(10^9); //converting to nm
disp(lambda,"The mean free path, in nm, is: ")

//Result
// The mean free path, in nm, is:
```

```
//        38.262803
```

Chapter 11

Nuclear Structure

Scilab code Exa 11.1 Density of Carbon12 nucleus

```
u= 1.66*(10^(-27)); //atomic mass unit , kg
Mc= 12*u; // atomic mass of Carbon -12, kg
R= 2.7; //radius of nucleus , fm
R=R*(10^(-15)); //converting to m
density= Mc/((4/3)*(%pi)*(R^3)); // kg/m^3
disp(density,"Density of Carbon 12 nucleus , in kg/m
    ^3, is: ")

//Result
// Density of Carbon 12 nucleus , in kg/m^3, is:
//     2.416D+17
```

Scilab code Exa 11.2 Repulsive electric force

```
r= 2.4; //distance between centre of the protons , fm
r= r*(10^(-15)); //converting to m
```

```
e= 1.6*(10^(-19)); //charge of an electron, C
Po= 8.85*(10^(-12)); //Permittivity of free space, F/m
K=1/(4*(%pi)*Po); //constant, N.m^2/C^2
F= K*(e^2)/(r^2); //N
disp(F,"The repulsive force, in N, is: ")

//Result
// The repulsive force, in N, is:
//    39.963576
```

Scilab code Exa 11.3 Proton in a magnetic field

```

//Part (a)
//Caption: find energy difference between spin-up ad spin-down states
B= 1; //strength of magnetic field, T
Mneutron= 3.152*(10^(-8)); //Magnetic moment for neutron, eV/T
Mproton= 2.793*Mneutron; //Magnetic moment for proton, eV/T
dE= 2*Mproton*B; //eV
disp(dE,"The energy difference, in eV, is: ")

//Result
// The energy difference, in eV, is:
//    0.0000002

//Part (b)
//Caption: find Larmor frequency for a proton in the field
h= 4.13*(10^(-15)); //Planck's constant, eV.s
Flarmor= dE/h; //Hz
Flarmor= Flarmor/(10^6); //converting to MHz
```

```
disp(Flarmor,"The Larmor frequency for a proton in
    the field , in MHZ, is: ")

//Result
// The Larmor frequency for a proton in the field ,
    in MHZ, is:
//     42.632136
```

Scilab code Exa 11.4 Atomic mass of Neon20 isotope

```

Ebinding= 160.647; //binding nergy , MeV
Mh= 1.007825; //Mass of H1 atom , u
Mn= 1.008665; //Mass of neutron , u
Z=10; //number of protons
N=10; //number of neutrons
Mneon= [(Z*Mh)+(N*Mn)]-[Ebinding/931.49]; //using
    Eqn 11.7
disp(Mneon,"The atomic mass of Neon 10 isotope , in
    terms of U, is: ")

//Result
// The atomic mass of Neon 10 isotope , in terms of U
    , is:
//    19.992438
```

Scilab code Exa 11.6 Binding energy of Zinc64 isotope

```

Z= 30; //proton number
N=34; //Neutron number

//Using Eqn 11.7
```

```
Mh= 1.007825; //Mass of H1 atom, u
Mn= 1.008665; //Mass of neutron, u
Mzinc= 63.929; //atomic mass of zinc, u
Ebinding= [(Z*Mh)+(N*Mn)-Mzinc]*931.49; //MeV
disp(Ebinding,"Binding energy of Zinc 64 isotope, in
    MeV, is: ")

//Result
// Binding energy of Zinc 64 isotope, in MeV, is:
//     559.22934


//Using semiempirical formula, Eqn 11.18, Page 407
a1= 14.1; //Mev
a2= 13.0; //MeV
a3= 0.595; //Mev
a4= 19.0;  //MeV
a5= 33.5; //MeV
A= Z+N;

E2= [(a1*A)-(a2*(A^(2/3)))-(a3*Z*(Z-1)/(A^(1/3)))-(
   a4*((A-2*Z)^2)/A)+(a5/(A^(3/4)))]; //MeV
disp(E2,"The binding energy using semi-empirical
   formula, in MeV, is: ")

//Result
// The binding energy using semi-empirical formula,
   in MeV, is:
//    561.718
```

Chapter 12

Nuclear Transformations

Scilab code Exa 12.2 Decay time for radon

```

Thalf= 3.82; //half-life in days, d
Lambda= 0.693/Thalf; //decay constant
p= 0.6; // 60.0 percent of sample
No= poly(0,'No'); //Number of undecayed nuclei, at
    time t=0
N= (1-p)*No; //Number of undecayed nuclei, at time t
k= 1-p; //ratio of N to No
t= (1/Lambda)*(log(k)); //decay time in days, d
t= t*(-1);

disp(t,"The decay time for Radon, in d, is: ")

//Result
// The decay time for Radon, in d, is:
//   5.0508378
```

Scilab code Exa 12.3 Activity of Radon

```
Thalf= 3.82; //half-life in days, d
Lambda= 0.693/(Thalf*86400); //decay constant, s
    ^(-1)
Wradon= 1.00; //weight of sample, mg
MRadon= 222; //atomic mass of sample, u
N= Wradon*(10^(-6))/(MRadon*(1.66*(10^(-27)))); //
    number of atoms
R= Lambda*N; //decays/sec
disp(R,"The activity of the sample, in decays/sec,
    is: ")

//Result
// The activity of the sample, in decays/sec, is:
//    5.698D+12
```

Scilab code Exa 12.4 Activity of Radon after a week

```
//Refer to Example 12.3

Ro= 155; //initial activity, Ci
Lambda= 2.11*(10^(-6)); //decay constant, s^(-1)
t= 7; //days
t= t*86400; //converting to s
R= Ro*((%e)^(-(Lambda*t))); //final activity, Ci
disp(R,"The activity after one week, in Ci, is: ")

//Result
// The activity after one week, in Ci, is:
//    43.262972
```

Scilab code Exa 12.5 Carbon dating

```
R= 13; //present activity,
Ro= 16; //activity of live wood
Thalf= 5760; //half life of radiocarbon, y
Lambda= 0.693/(Thalf); //decay constant, y^(-1)
t= (1/Lambda)*(log(Ro/R)); //age of sample, y
disp(t,"The age of the wooden sample, in years, is:
   ")

//Result
// The age of the wooden sample, in years, is:
//     1725.8337
```

Scilab code Exa 12.6 Half life of Uranium238

```
Thalf1= 2.5*(10^5); //half-life of U-234, y
AtomicRatio= 1.8*(10^4); //atomic ratio of u-238 and
    U-234 in the sample
Thalf2= AtomicRatio*Thalf1; //using Eqn12.9
disp(Thalf2,"The half-life of Uranium-238, in years,
    is: ")

//Result
// The half-life of Uranium-238, in years, is:
//     4.500D+09
```

Scilab code Exa 12.7 Daughter nuclide of Polonium

```
Npolonium= 84; //atomic number of polonium
Nalpha= 2; //atomic number of alpha particle
```

```
Z= Npolonium-Nalpha; //atomic number of daughter nuclide
Mpolonium= 209.9829; //mass number of polonium, u
Malpha= 4.0026; //mass number of alpha particle, u
A= Mpolonium-Malpha; //mass number of daughter nuclide
disp(Z,"The daughter nuclide has atomic number: ")
disp(A,"and mass number: ")

// The daughter nuclide has atomic number:
//    82.

// and mass number:
//     205.9803.

Ealpha= 5.3; //energy of alpha particle, MeV
Q= Mpolonium*Ealpha/A; //disintegration energy, MeV
Mq= Q/931; //mass equivalent for Q, u
Mnuclide= Mpolonium-Malpha-Mq; //u
disp(Mnuclide,"The atomic mass of the daughter nuclide is: ")
//Result
// The atomic mass of the daughter nuclide is:
//    205.9745
```

Scilab code Exa 12.8 Absoprtion of neutron by Cadmium

```

CrossSection= 2*(10^4); // capture cross section of Cadmium-113
CrossSection= CrossSection*(10^(-28)); // converting to m^2
Mcadmium= 112; //mean atomic mass of cadmium, u
density= 8.64*(10^3); //density of cadmium sheet used, kg/m^3
```

```

//Part (a)

t= 0.1; //hickness of sheet used, mm
t= t*10^(-3); //converting to m
p= 12; //percent of Cadmium-113 in natural cadmium
u= 1.66*(10^(-27)); //atomic mass unit, kg
n= (p/100)*density/(Mcadmium*u); //number of atoms, atoms/m^3
Fabsorbed= 1- ((%e)^((-n)*(CrossSection)*(t))); //absorbed fraction
disp(Fabsorbed,"The fraction of incident beam absorbed is: ")

//Result
// The fraction of incident beam absorbed is:
//   0.6721891

//Part (b)

t2= (-(log(0.01)))/(n*CrossSection); //required thickness, m
t2= t2*10^(3); //converting to mm
disp(t2,"The thickness required to absorb 99 percent of incident thermal neutrons, in mm, is: ")

//Result
// The thickness required to absorb 99 percent of incident thermal neutrons, in mm, is:
//   0.4129018
```

Scilab code Exa 12.9 Thermal neutrons

```
//refer to Example 12.8

```

```
CrossSection= 2*(10^4); // capture cross section of Cadmium-113, b
CrossSection= CrossSection*(10^(-28)); // converting to m^2
n= (12/100)*(8.64*10^3)/(112*(1.66*10^(-27))); // number of atoms, atoms/m^3
Lambda= 1/(n*CrossSection); //mean free path, m
Lambda= Lambda*10^3; //converting to, mm
disp(Lambda,"The mean free path, in mm, is: ")

//Result
// The mean free path, in mm, is:
//    0.0896605
```

Scilab code Exa 12.10 Irradiation of gold foil

```

Thalf= 2.69; //half life of gold,d
Lambda= 0.693/(Thalf*86400); //decay constant, s^(-1)
R= 200; //required activity, mCi
R= R*10^(-6); //converting to Ci
dN= R/(Lambda/(3.70*10^(10))); //atoms
Wgold= 10; //mass of foil, mg
u= 1.66*(10^(-27)); //atomic mass unit, kg
Mgold= 197; // u
n2= Wgold*10^(-6)/(Mgold*u); //total no. of atoms
phi= 2*10^(16); //flux, neutrons/m^2
CrossSection= 99*10^(-28); //m^2
dT= dN/(phi*n2*CrossSection);  //s
disp(dT,"The irradiation period required, in seconds, is: ")

//Result
//The irradiation period required, in seconds, is:
```

```
//       409.89595
```

Scilab code Exa 12.11 Alpha particle in lab system

```

m1= 14.00307; //u
m2= 4.00260; //u
m3= 1.00783; //u
m4= 16.99913; //u
k= m1+m2-m3-m4; // difference in total mass of reactants and products , u
Q= k*931.5; //energy exchanged , MeV
KEcm= -Q; //minimum KE needed in centre of mass system , MeV
KElab= KEcm*(m2+m1)/m1; //minimum KE in laboratory system
disp(KElab,"The minimum KE required by the alpha particle , in MeV, is: ")

//Result
// The minimum KE required by the alpha particle , in MeV, is:
//     1.5451071
```