# Scilab Textbook Companion for Introduction To Special Relativity And Space Science by S. P. Singh[1]

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September 2, 2013

[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:** Introduction To Special Relativity And Space Science

**Author:** S. P. Singh

**Publisher:** Wiley, India

**Edition:** 1

**Year:** 2012

**ISBN:** 9788126532544

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

# Interference Diffraction and Polarization

**Scilab code Exa 1.1** Determination of slit separation in Young double slit experiment

```
clc //Given that
Beta=0.10//fringe width in cm
D=200// separation between source and screen in cm
lambda=0.00055// wavelength of incident light in cm
//Sample Problem 1 Page No. 46
printf ("\n # Problem 1 # \n")
d= (D*lambda)/ (10*Beta)
printf (" \n Standard formula used \n  beta= lambda*D/d \n")

printf ("\n Separation between sources is %f cm. \n",d)
```

**Scilab code Exa 1.2** Determination of wavelength of light in Youngs double slit experiment

```
clc
//Given that
D=80// separation between source and screen in cm
d=0.18// separation between sources in cm
n=4// order of fringe
x_n=1.08// distance from central bright fringe in cm
//Sample Problem 2 Page No. 47
printf("\n # Problem 2 # \n")
printf(" \n Standard formula used \n    x_n= n*lambda
   *D/d \n")

lambda=d*x_n/(D*n)*1e7
printf("\n Wavelength of light used is %d Angstrom."
   , lambda)
```

**Scilab code Exa 1.3** Determination of wavelength of light in biprism experiment

```
clc
//Given that
beta=0.0320//fringe width in cm
D=100// separation between source and screen in cm
d=0.184// separation between sources in cm
//Sample Problem 3 Page No. 47
printf ("\n # Problem 3 # \n")
```

```
printf(" \n Standard formula used    beta=lambda*D/d
   \n")

lambda=d*beta/D*1e8
printf("\n Wavelength of light used is %d Angstrom."
   ,lambda)
```

**Scilab code Exa 1.4** Determination of wavelength of light in biprism experiment

```
clc
//Given that
beta=0.02//fringe width in cm
D=100// separation between source and screen in cm
u=30// separation between slit and convex lens in cm
I=0.7// separation between two images of slits on
   screen in cm
//Sample Problem4 Page No. 47
printf("\n # Problem 4 # \n")
printf(" \n Standard formula used \n beta=lambda*D/d
    \n")

v=100-u
O=I*u/v
d=O
lambda=d*beta/D*1e8
printf("\n Wavelength of light used is %d Angstrom."
   , lambda)
```

**Scilab code Exa 1.5** Determination of wavelength of light in biprism experiment

```
clc
//Given that
x_n=1.88// fringe separation of nth fringe from
    central fringe in cm
N=20// order of fringe
beta=0.02//fringe width in cm
D=120// separation between source and eyepiece in cm
d=0.076// separation between sources in cm
//Sample Problem 5 Page No. 47
printf("\n # Problem 5 # \n")
printf(" \n Standard formula used \n    beta= lambda
    *D/d \n")
beta=x_n/N // calculation of angle formed
lambda=d*beta/D*1e8 // calculation of Wavelength of
    light
printf("\n Wavelength of light used is %d Angstrom.
    ", lambda)
```

---

**Scilab code Exa 1.6** Determination of fringe width in biprism experiment

```
clc
//Given that
mu = 1.5 // refractive index of plane glass prism
theta = %pi / 180 // angle of prism
y1 = 10 // separation between slit and biprism in cm
y2 = 100 //separation sbetween biprism and screen in
     cm
lambda = 0.00005893// wavelength of incident light
    in cm
//Sample Problem 6 Page No. 48
```

```
printf("\n # Problem 6 # \n")
printf("\n Standard formula used \n Beta = (D *
   lambda) / d")
d = 2 * ( mu -1) * theta * y1
D =  y1 + y2
Beta = (D * lambda) / d
printf("\n Fringe width observed at distance 1 meter
     is %f m", Beta)
```

**Scilab code Exa 1.7** Calculation of angle at vertex of biprism

```
clc
//Given that
mu=1.52// refractive index of plane glass prism
theta=%pi/180// angle of prism
y1=25// separation between slit and biprism in cm
y2=175//separation between biprism and screen in cm
lambda=0.000055// wavelength of incident light in cm
beta=0.02//fringe width in cm
//Sample Problem 7 Page No. 49
printf("\n # Problem 7 # \n")
printf(" \n Standard formula used \n   beta= lambda*
   D/d. \n")
D=y1+y2
d= (D*lambda)/beta
theta=d/(2*(mu-1)*y1)
vertex_angle=180-(2*theta*180/%pi)
printf("\n Vertex angle of biprism   is %f degree.",
   vertex_angle)
```

**Scilab code Exa 1.8** Determination of thickness of glass sheet introduced in Youngs double slit experiment

```
clc
//Given that
mu=1.60// refractive index of plane glass prism
lambda=0.0000589// wavelength of incident light in
    cm
N=15// order of fringe
//Sample Problem 8 Page No. 49
printf("\n # Problem 8 # \n")
printf(" \n Standard formula used \n    del_x = D/2d
    *(mu-1)*t  \n")
t=N*lambda/(mu-1)
printf("\n Thickness of sheet is %e cm.", t)
```

---

**Scilab code Exa 1.9** Determination of refractive index of glass sheet introduced in biprism experiment

```
clc
//Given that
t=0.00035// thickness of glass sheet in cm
lambda=0.000055// wavelength of incident light in cm
N=4// order of fringe
//Sample Problem 9 Page No. 50
printf("\n # Problem 9 # \n")
printf(" \n Standard formula used \n    (mu      1 )*t
     = n* lambda \n")
```

```
mu=N*lambda/t+1
printf("\n Refractive index of sheet is %f .", mu)
```

**Scilab code Exa 1.10** Determination of lowest order which will be absent from light reflected from soap film

```
clc
//Given that
t = 5e-5 // thickness of soap film in cm
theta = 35 // angle of view in degree
mu = 1.33 // refractive index of soap film
// sample problem 10 page No. 50
printf("\n # Problem 10 # \n")
a = 0
printf("Standard formula used \n\t 2*mu*t*cos(r) = n
   *lambda ")
r = asin (sin(theta * %pi /180) / mu)
for n = 1:3
    lambda = 2 * mu * t * cos(r) / n
    if lambda > t then
        a = a + 1
    end
end
printf (" \n\n The lowest order n = %d will be
   absent in visible region.",a)
```

**Scilab code Exa 1.11** Determination of wavelength of light in biprism experiment

```
clc
//Given that
D=120// separation between source and screen in cm
d=0.00075// separation between sources in cm
l=1.888// transverse distance moved by eyepiece in cm
N=25// order of fringe
//Sample Problem 11 Page No. 50
printf("\n # Problem 11 # \n")
printf(" \n Standard formula used \n beta=lambda*D/d \n")
lambda=d*l/(D*N)*1e10
printf("\n Wavelength of light used is %d Angstrom.", lambda)
```

**Scilab code Exa 1.12** Determination of wavelength of light in Newtons ring experiment

```
clc
//Given that
D15=0.59// diameter of 15th newton s ring in cm
D5=0.336// diameter of 5th newton s ring in cm
R=100// radius of Plano convex lens in cm
//Sample Problem 12 Page No. 51
printf("\n # Problem 12 # \n")
p=15-5
printf(" \n Standard formula used \n D_a^2      D_b^2 = 4*p*R*lambda \n")

lambda=(D15^2 - D5^2)/(4*p*R)*1e8
printf("\n Wavelength of light used is %d Angstrom.", lambda)
```

**Scilab code Exa 1.13** Calculation of refractive index of air

```
clc
//Given
t=40// length of tube in cm
lambda=5e-5// wavelength of incident light in cm
n=150// order of fringe
//Sample Problem 13 Page No. 52
printf("\n # Problem 13 # \n")
printf(" \n Standard formula used \n   (mu    1 )*t
    = n* lambda \n")
t=n*lambda/t+1
printf("\n Refractive index of oil film is %f  .", t
   )
```

---

**Scilab code Exa 1.14** Calculation of thickness of air film

```
clc
//Given
no_fringe = 250 // Number of fringes observed
   through telescope
lambda1 = 4e-5// wavelength of incident light in cm
lambda2 = 6.5e-5 // wavelength of incident light in
   cm

//Sample Problem 14 Page No. 52
printf("\n # Problem 14 # \n")
```

```
printf(" \n Standard formula used \n  2*t = p*lambda ")
p =  no_fringe * lambda1 / (lambda2- lambda1)
t = p * lambda2 / 2
printf("\n Thickness  of air film  is %f cm.  ", t)
```

**Scilab code Exa 1.15** Calculation of thickness of oil film

```
clc
//Given
mu_oil=1.3// refractive index of oil
mu_glass=1.5//refractive index of glass
lambda1=5e-7// wavelength of incident light in cm
lambda2=7e-7// wavelength of incident light in cm

//Sample Problem 15 Page No. 52
printf("\n # Problem 15 # \n")
printf(" \n Standard formula used \n   2*mu*t*cos r = (p +0.5)*lambda \n")
p= ((lambda2+lambda1)/ (lambda2-lambda1))/2
t= ((p+0.5)*lambda1)/ (2*mu_oil)*1e10
printf("\n Thickness of oil film  is %d Angstrom.  ",ceil(t))
```

**Scilab code Exa 1.16** Determination of diameter fourth bright ring in Newtons ring experiment

```
clc
//Given
```

```
lambda=5.6e-5// wavelength of incident light in cm
f=4//focal length in meter
mu=1.5// refractive index of glass\
n=4// order of fringe
//Sample Problem 16 Page No. 53
printf ("\n # Problem 16 # \n")
printf(" \n Standard formula used \n   D_n= sqrt
    (2*(2*n-1)*lambda*R \n")
R= (mu-1)*2*f
D_4=sqrt (2*(2*n-1)*lambda*R*100)
printf("Diameter of 4th bright fringe is %f cm.",D_4
    )
```

**Scilab code Exa 1.17** Determination of radius of curvature of Plano convex lens used in Newtons ring experiment

```
clc
//Given
D_5=0.336// diameter of fifth ring in cm
D_15=0.59// diameter of fifteenth ring in cm
lambda=5.893e-5// wavelength of incident light in cm
p=10
//Sample Problem 17 Page No. 53
printf("\n # Problem 17 # \n")
printf(" \n Standard formula used \n   D_(n+p) ^2
        D_n^2 = 4*p*R*lambda \n")
r= ((D_15^2-D_5^2)/ (4*p*lambda))
printf("\n  Radius of curvature of Plano-convex lens
     is %f cm. ",r)
```

**Scilab code Exa 1.18.1** Determination of radius of curvature of Plano convex lens used in Newtons ring experiment

```
clc
//Given
D_10=0.5// diameter of 10th dark ring
lambda=5.9e-5// wavelength of incident light in cm
n=10// order of ring
//Sample Problem 18a Page No. 54
printf("\n # Problem 18a # \n")
printf(" \n Standard formula used \n    r_n^2 = n*lambda*R \n")
r=D_10/2
R=r^2/ (n*lambda)/1000
printf("Radius of curvature is %f m.\n ",R)
```

**Scilab code Exa 1.18.2** Determination of thickness of air film in Newtons ring experiment

```
clc
//Given
lambda=5.9e-5// wavelength of incident light in cm
n=10// order of ring
//Sample Problem 18b Page No. 54
printf("\n # Problem 18b # \n")
printf(" \n Standard formula used \n    2t = n*lambda \n")
t=n*lambda/200
```

```
printf(" Thickness of air film is %e m.\n ",t)
```

**Scilab code Exa 1.19** Determination of radius of curvature of Plano convex lens used in Newtons ring experiment

```
clc
//Given
mu=4/3
D_10=0.6// diameter of tenth ring in cm
lambda=6.0e-5// wavelength of incident light in cm
n=10// order of ring

//Sample Problem 19 Page No. 54
printf("\n # Problem 19 # \n")
printf(" \n Standard formula used \n    D_n^2 = 4*n*
   lambda*R/mu \n")
R= (mu*D_10^2/ (4*n*lambda))

printf(" Radius of curvature of lens is %d cm.\n ",
   ceil(R))
```

**Scilab code Exa 1.20** Determination of wavelength of light using grating

```
clc
//Given
grating_element=6000// lines per centimeter
theta=30// angle of second order spectral line in
   degree
n=2// order
```

```
//Sample Problem 20 Page No. 54
printf("\n # Problem 20 # \n")
printf(" \n Standard formula used \n   n*lambda= (a+
   b)*sin(theta) \n")

lambda=sin(theta*%pi/180)/(grating_element*n)
printf(" Wavelength is %e cm.\n",lambda)
```

**Scilab code Exa 1.21** Determination of highest order which can be seen by a grating

```
clc
//GivenS
lambda=6.2e-5// wavelength of monochromatic light in
    cm
grating_element= 1/5000// lines per centimeter
theta=90// angle of second order spectral line in
   degree

//Sample Problem 21 Page No. 55
printf("\n # Problem 21 # \n")
printf(" \n Standard formula used \n   n*lambda= (a+
   b)*sin(theta)  \n")
n=grating_element/lambda
printf(" Maximum order n = %d may be seen in between
    the given wavelength spectrum.\n ",n)
```

**Scilab code Exa 1.22** Determination of dispersive power grating in third order spectrum

```
clc
//Given
lambda=5.5e-5// wavelength of monochromatic light in
   cm
grating_element=1/4000// lines per centimeter
n=3// order of spectrum

//Sample Problem 22 Page No. 55
printf("\n # Problem 22 # \n")
printf(" \n Standard formula used \n   n*lambda= (a+
  b)*sin(theta)\n")
sin_theta=n*lambda/grating_element
cos_theta=sqrt(1-sin_theta^2)
disp_pow=n/ (grating_element*cos_theta)
printf (" Dispersive power   is %d. \n ",disp_pow)
```

**Scilab code Exa 1.23.1** Determination of clearly observation between two wavelengths in first order by using grating

```
clc
// Given That
lambda1=5.89e-5// wavelength in cm
lambda2=5.896e-5//wavelength in cm
n=1// for second order spectrum
t = 2 // width of detraction grating
grating_element = 425 // no. of lines per cm
//Sample Problem 23a Page No. 56

printf("\n # Problem 23a # \n")
printf(" \n Standard formula used \n   lambda /
```

```
    d_lambda = n*N \n")
total_line = t * grating_element
printf("\n Total number of lines on diffraction
    grating is %d \n  So",total_line)
N=lambda1/ (lambda2-lambda1)/n
if (N > total_line) then
printf ("\n  Lines will not be resolved in %d order
    .",n)
printf("\nas %d  lines are required  for diffraction
     ", N)
else printf("\nas %d  lines are required  for
    diffraction are.  ", N)
     printf ("  Lines will be resolved in %d order",
        n)
end
```

**Scilab code Exa 1.23.2** Determination of clearly observation between two wavelengths in second order by using grating

```
clc
// Given That
lambda1=5.89e-5// wavelength in cm
lambda2=5.896e-5//wavelength in cm
n=2// for second order spectrum
t = 2 // width of diffraction grating
grating_element = 425 // no. of lines per cm
//Sample Problem 23b Page No. 56

printf("\n # Problem 23b # \n")
printf(" \n Standard formula used \n   lambda /
    d_lambda = n*N \n")
total_line = t * grating_element
printf("\n Total number of lines on diffraction
```

```
grating %d \n \n So",total_line)
N=lambda1/ (lambda2-lambda1)/n
if (N > total_line) then
printf ("\n  ,Lines will not be resolved in %d order.",n)
printf("\nas %d  lines are required  for diffraction are  ", N)
else printf ("  Lines will be resolved in %d order",n)
    printf("\nas %d  lines are required  for diffraction are . ", N)
end
```

**Scilab code Exa 1.24** Calculation of maximum number of lines two just resolve two wavelengths in second order

```
clc
// Given That
lambda1=5.89e-5// wavelength in cm
lambda2=5.896e-5//wavelength in cm
t=2.5// width of grating in cm
n=2// for second order spectrum
//Sample Problem 24 Page No. 56

printf("\n # Problem 24 # \n")
printf(" \n Standard formula used \n   lambda / d_lambda = n*N \n")
N=lambda1/ (lambda2-lambda1)/n
grating_element=N/t
printf(" Minimum number of lines required is %f .\n",grating_element)
```

**Scilab code Exa 1.25** Calculation of maximum number of lines two just resolve two wavelengths in first order

```
clc
// Given That
a=12e-5// slit width in cm
lambda1=5.89e-5// wavelength in cm
lambda2=5.896e-5//wavelength in cm
n=2// for second order spectrum
//Sample Problem 25 Page No. 56
printf("\n # Problem 25 # \n")
printf(" \n Standard formula used \n   lambda /
   d_lambda = n*N \n\n")
d_lambda = lambda2-lambda1
grating_element= lambda1/ (d_lambda*n)

printf(" Minimum number of lines required is %d . \n
    ", ceil(grating_element))
```

---

**Scilab code Exa 1.26** Determination of half angular width of central maxima in Fraunhofer diffraction pattern

```
clc
// Given That
a = 12e-5 // slit width in cm
lambda = 6e-5 // wavelength in cm
//Sample Problem 26 Page No. 57
printf("\n # Problem 26 # \n")
```

```
printf(" \n Standard formula used \n   a*sin(theta ) = lambda \n")
theta = asin((lambda / a))
printf(" Half angular width of central bright maxima is %d degree .", ceil (theta * 180 / %pi) )
```

**Scilab code Exa 1.27** Calculation of resolving power of grating in first order

```
clc
// Given That
lambda1 = 5.9e-5 // wavelength in cm
lambda2 = 5.896e-5 //wavelength in cm
lambda = 5.89e-5 // wavelength in cm
grating_element = 4000 // lines per cm
t = 4 // width of grating in  cm
n = 1 // for first order spectrum
//Sample Problem 27 Page No. 58
printf("\n # Problem 27 # \n")
printf(" \n Standard formula used \n   lambda / d_lambda = n* N   )\n")

N = t * grating_element
 Resolv_pow = lambda /(lambda2 - lambda)
 N = Resolv_pow / n

 if (grating_element > N  )  then
     printf("Grating will well resolve two spectral lines. \n")
     end
```

**Scilab code Exa 1.28** Calculation of distance between centre and first fringe

```
clc
// Given That
aperture=6.4e-3// linear aperture in cm
lambda=6.24e-5// wavelength in cm
f=50// separation between lens and screen in cm
n=1// for first order spectrum
//Sample Problem 28 Page No. 58
printf("\n # Problem 28 # \n")
printf(" \n Standard formula used \n   a*sin(theta )
    = lambda \n")
sin_theta=n*lambda/aperture
d=f*sin_theta
printf("\n Distance between the center and the first
    fringe is %f cm.\n",ceil(d*100)/100)
```

---

**Scilab code Exa 1.29** Comparison of intensities of ordinary and extra ordinary light

```
clc
// Given That
theta = 60 // angle between plane of vibration of
   incident beam with optic axis

//Sample Problem 29 Page No. 859
printf("\n # Problem 29 # \n ")
```

```
printf("Standard formula used is \n I = A^2*cos^2(
    theta) \n")
ratio = (tan(theta*%pi /180))^2    // ratio of
    extraordinary and aordinary intensites
printf("Ratio of extraordinary and ordinary
    intensites is %f .", ratio)
```

**Scilab code Exa 1.30** Calculation of thickness of half wave plate

```
clc
// Given That
mu_e = 1.553 // refractive index of quartz plate for
     extra ordinary light
mu_o = 1.544 // refractive index of quartz plate for
     ordinary light
lambda = 5.89e-5 // wavelength of light in Angstrom.
//Sample Problem 30 Page No. 859
printf("\n # Problem 30 # \n ")
printf("Standard formula used is \n lambda= 2t(mu_e-
    mu_o) \n")
t = lambda / (2 * (mu_e - mu_o))
printf("Thickness of half wave plate of quartz is %e
     cm.", t)
```

**Scilab code Exa 1.31** Determination of least thickness to get a plane polarized light

```
clc
// Given That
```

```
lambda=5e-5// wavelength in cm
mu_e=1.5533// refractive index for extraordinary
    light
mu_o=1.5422// refractive index for ordinary light
//Sample Problem 31 Page No. 59
printf ("\n # Problem 31 # \n ")
printf (" \n Standard formula used \n   lambda= 2t (
    mu_e−mu_o)\n")
t=lambda/ (2*(mu_e-mu_o)) // calculation of
    Thickness of half wave plate of quartz
printf ("Thickness of half wave plate of quartz is
    %e cm", t)
```

**Scilab code Exa 1.32** Calculation of difference between refractive indices

```
clc
// Given That
lambda=5.89e-5// wavelength in cm
rotation=(%pi/18)// rotation of plane of
    polarization in degree per cm

//Sample Problem 32 Page No. 60
printf("\n # Problem 32 # \n ")
printf(" \n Standard formula used \n   delta=pi*d*
    del_mu/lambda \n")
del_mu=rotation*lambda/ (%pi)
printf("Difference in refractive indices of
    substance is %e .\n",del_mu)
```

**Scilab code Exa 1.33** Determination of specific rotation of sugar solution

```
clc
// Given That
rotation=13.2// in degree
conc=0.1// gram per cubic cm
l=2// length of tube in dm
//Sample Problem 33 Page No. 60
printf("\n # Problem 33 # \n ")
printf(" \n Standard formula used \n    delta=pi*d*
   del_mu/lambda \n")
s= (rotation*(%pi/180))/ (l*conc)
specific_rotation=s*180/%pi
printf("Specific rotation of sample is %d degree. \n
   ",specific_rotation)
```

# Chapter 2

# Electromagnetic Waves

**Scilab code Exa 2.2** Calculation of energy stored in cylinder and wave Intensity

```
clc
// Given That
E_0 = 50 // magnitude of electric field  in N/C
l = 100 // radius of cylinder in cm
a = 5 // area of cross section in cm^2
c = 3e8 // speed of light in m/s
epsilon_0 = 8.85e-12 // permittivity of free space
//Sample Problem 2 Page No. 79
printf("\n # Problem 2  # \n ")
v = a*1e-4 *l*1e-2//calculation of volume of cylinder
u = (1/2)*epsilon_0*E_0^2//calculation of energy intensity
U = v*u//calculation of Energy contained in cylinder
I = u*c//calculation of Intensity of wave
 printf("Energy contained in cylinder is %eJ \n", U)
printf("Intensity of wave is %fW/m^2", I)
```

**Scilab code Exa 2.3** Determination of amplitude of electric field

```
clc
// Given That
I = 2.4 // intensity of radiation in Watt per meter square
epsilon_0 = 8.85e-12
c = 3e8
//Sample Problem 3 Page No. 80
printf("\n # Problem 3 # \n ")
E = sqrt ((2* I)/ (c * epsilon_0)) // calculation of amplitude of electric field is
printf("Amplitude of electric field is %f N/C \n", E )
```

**Scilab code Exa 2.4** Calculation of energy stored in a length of laser beam

```
clc
// Given That
l = 75 // length of laser beam in cm
power = 6e-3 // power of beam in mW
c = 3e8
//Sample Problem 4 Page No. 80
printf("\n # Problem 4 # \n ")
t = l / ( c * 100) //calculation of time taken to cover distance
U =  power/1000 * t//calculation of Energy stored in given length
```

```
printf("Energy stored in given length is %e J \n",
    U)
```

**Scilab code Exa 2.6** Calculation of maximum Electric and magnetic force on an electron due to EM wave

```
clc
// Given That
E_0 = 300 // maximum electric field in
    electromagnetic wave in w/m
v = 2e8 // speed of moving electron in m/s along y -
    axis
c = 3e8 // speed of light in m/s
q = 1.6e-19 // charge on electron in coulomb
//Sample Problem 6 Page No. 81
printf ("\n # Problem 6 # \n ")
B_0  = E_0 / c // calculation of magnitude of
    maximum magnetic field
F_e = q*E_0 // calculation of electromagnetic force
    on electron in N
F_b = q*v*B_0 // calculation of magnetic force on
    electron in N
printf ("The maximum electric force on electron is
    %e N along y -axis \n", F_e)
printf("The maximum magnetic force on electron is
    %e N along z - axis\n", F_b)
```

**Scilab code Exa 2.7** Calculation of average solar energy flux and pressure applied by it on earth

```
clc
// Given That
d = 1.5e11 // separation between earth and sun in
   meter
power_sun = 3.8e26// power radiated by sun in W
c = 3e8
//Sample Problem 7 Page No. 82
printf("\n # Problem 7 # \n ")
s = power_sun /(4 * %pi * (d^2)) //calculation of
   Energy received per unit surface area per unit
   time
p =  s / c // calculation of Pressure applied by sun
    radiations on earth
printf("Energy received per unit surface area per
   unit time is %f", s)
 printf("\n Pressure applied by sun radiations on
    earth is %e N/m^2 \n", p)
```

**Scilab code Exa 2.8** Calculation of electric flux through plane square due to uniform electric field

```
clc
// Given That
E = 100 // magnitude of electric field perpendicular
    to X axis in N/C
r = 10 // radius of circle in cm
//Sample Problem 8 Page No. 83
printf("\n # Problem 8  # \n ")
ds = (r*1e-2)^2 //calculation of area of coil
phi = E*ds //calculation of Flux through coil
  printf("Flux through coil is  %d Nm/C \n", phi)
```

**Scilab code Exa 2.9** Calculation of electric flux through plane circle due to uniformly distributed charged sheet

```
clc
// Given That
sigma = 2e-6 // surface charge density in c/m^2 on
   XY plane
theta = 60 // angle between normal and X axis on
   degree
r = 10 // radius of circle in cm
epsilon_0 = 8.85e-12 // permitivity of free space
//Sample Problem 9 Page No. 84
printf("\n # Problem 9  # \n ")
printf("standard formula used \n phi = sigma*A*cos(
   theta)/(2*epsilon_0) \n\n")
phi = sigma* %pi*(r*1e-2)^2 * cos (theta*%pi/180) /
   (2*epsilon_0) //calculation of Flux through coil
 printf("Flux through coil is  %e Nm^2/C. \n", phi)
```

**Scilab code Exa 2.10** Determination of charge inside sphere with the help of electric field

```
clc
// Given That
A = 200 // magnitude of electric field in V/m^2
epsilon_0 = 8.85e-12 // permittivity of free space
a = 20 // radius of sphere in cm
//Sample Problem 10Page No. 84
```

```
printf("\n # Problem 10 # \n ")
q = 4*%pi * epsilon_0*A*(a*1e-2)^3  //calculation of
    Charge contained in sphere
 printf("Charge contained in sphere is  %e C. \n", q
    )
```

**Scilab code Exa 2.11** Calculation of induced emf current due to changing area and

```
clc
// Given That
B = 0.2 //  magnetic field in T
del_r = 1 // rate of change of decrement in loop
   radius in cm/s
r =  20 // radius of frame in cm
R = 10 // resistance of frame in m ohm
//Sample Problem 11 Page No. 84
printf("\n # Problem 11 # \n ")
e =  2* %pi * B *r *1e-2* del_r*1e-2 // magnitude of
    emf induced in coil
i = (e) / (R*1e-3) //calculation of Current induced
   due to changing magnetic field
 printf("Current induced due to changing magnetic
    field is %f A \n", i)
```

**Scilab code Exa 2.12** Calculation of induced current due to changing magnetic field

```
clc
```

```
// Given That
phi = 0.02 // rate of change of magnetic field in T/
    s
r =  2 // radius of frame in cm
R = 2 // resistance of frame in m ohm
//Sample Problem 12 Page No. 85
printf("\n # Problem 12 # \n ")
a = %pi * (r*1e-2)^2
e =  a * phi // magnitude of emf  induced in coil
i = (e) / (R*1e-3)
 printf("Current induced due to changing magnetic
     field is %f mA \n", i*1000)
```

**Scilab code Exa 2.13** Calculation of poynting vector at the surface of sun

```
clc
// Given That
r = 7e8 // radius sun in meter
power_sun = 3.8e26// power radiated by sun in W
//Sample Problem 13 Page No. 86
printf("\n # Problem 13 # \n ")
s = power_sun /(4 * %pi * (r^2)) //calculation of
    Pressure applied by sun radiations on earth
 printf("Pressure applied by sun radiations on earth
     is %e W/m^2 \n", s)
```

**Scilab code Exa 2.14** Calculation of amplitude of electric and magnetic fields of solar radiation

```
clc
// Given That
solar_const = 2 // energy received by earth from sun
    in Cal/min cm2
mu_not = 1.2566e-6 // universal constant
epsilon_not = 8.85e-12 // universal constant
//Sample Problem 14 Page No. 86
printf("\n # Problem 14 # \n ")
ratio = sqrt(mu_not / epsilon_not) // constant
E = sqrt (ratio *4.2 * solar_const / 6e-3)
E_not = E * sqrt(2) //calculation of Amplitude of
   electric  vectors
H_not = E_not / ratio//calculation of Amplitude of
   magnetic vectors
 printf("Amplitude of electrical and magnetic
    vectors are given as %f V/m and %f A/m",E_not,
    H_not)
```

**Scilab code Exa 2.15** Calculation of average value of intensity of electric field radiation

```
clc
// Given That
r = 1 // distance from lamp in meter
power = 100// power radiated by lamp in W
mu_not = 1.2566e-6 // universal constant
epsilon_not = 8.85e-12 // universal constant
//Sample Problem 15 Page No. 87
printf("\n # Problem 15 # \n ")
s = power /(4 * %pi * (r^2)) //calculation of
   intensity at a distance
ratio = sqrt(mu_not / epsilon_not) //calculation of
   a constant
```

```
E = sqrt (ratio * s) //calculation of Average value
    of intensity of electric field
 printf("Average value of intensity of electric
    field is %f V/m \n", E)
```

# Chapter 3

# Dual Nature of Light

**Scilab code Exa 3.1** Calculation of velocity of ejected photoelectrons

```
clc
//Given that
h = 6.6e-34 // plank's constant
nu = 2e15 // frequency in Hz
phi = 6.72e-19
m = 9e-31
//Sample Problem 1 Page No. 135
printf("\n\n\n # Problem 1 # \n")
printf("Standard formula Used \n ( 1/2)*m*v^2 = h*nu
    - phi")
v = sqrt ((h * nu)/ m ) //calculation of maximum
    velocity of photoelectron
printf("\n Maximum velocity of photoelectron can be
    %e m/s.. ", v)
```

**Scilab code Exa 3.2** Calculation of energy of ejected photoelectrons

```
clc
//Given that
h = 6.6e-34 // plank's constant
lambda_threshold = 2.4e-7 // threshold wavelength in cm
lambda = 2e-7 // wavelength of irradicated light in photo emmission
c = 3e8
//Sample Problem 2 Page No. 135
printf("\n # Problem 2 # \n")
printf("\n Standard formula Used \n E = h * (nu1 nu2)")
E = h * c * ((lambda_threshold - lambda)/(lambda * lambda_threshold))/1.6e-19 // calculation of nergy of photoelectrons
printf("\n Energy of photoelectrons emitted is %f eV", E)
```

---

**Scilab code Exa 3.3** Determination of shortest wavelength emitted in X ray operation

```
clc
//Given that
applied_voltage = 4e4 // in volt
h = 6.624e-34 // plank's constant
c = 3e8 // speed of light
e = 1.6e-19 // charge on electron
//Sample Problem 3 Page No. 136
printf("\n\n\n # Problem 3 # \n")
printf("\n Standard formula Used \n E = h*c/lambda")
lambda = h * c / ( e * applied_voltage) *1e10 //
```

```
    calculation of Shortest wavelength emitted
printf("\n Shortest wavelength emitted is %f
    Angstrom.", lambda)
```

**Scilab code Exa 3.4** Calculation of velocity of a moving electrons

```
clc
//Given that
E = 1e3 // energy of moving electron in eV
h = 6.624e-34 // plank's constant
c = 3e8 // speed of light
e = 1.6e-19 // charge on electron
m_e = 9.1e-31
//Sample Problem 4 Page No. 136
printf("\n\n\n # Problem 4 # \n")
printf("\n Standard formula Used \n E =(1/2)*m *v^2"
    )
v = sqrt(2 * E * 1.6e-19/ m_e) //calculation of
    Velocity of moving electron
printf("\n Velocity of moving electron is %e  m/s.",
     v)
```

**Scilab code Exa 3.5** Determination of threshold wavelength for photoemission

```
clc
//Given that
phi = 6 // work function in eV
h = 6.624e-34 // plank's constant
```

```
c = 3e8 // speed of light
e = 1.6e-19 // charge on electron
m_e = 9.1e-31
//Sample Problem 5 Page No. 137
printf("\n\n\n # Problem 5 # \n")
printf("\n Standard formula Used \n phi = h * nu")
lambda = h * c / (phi * e) * 1e10//calculation of Longest wavelength to eject electron
printf("\n Longest wavelength to eject electron is %d Angstroms. ", lambda)
```

**Scilab code Exa 3.6** Determination of Compton shift of X ray photon

```
clc
//Given that
theta = %pi/2 // scattering angle of photon
h = 6.624e-34 // plank's constant
c = 3e8 // speed of light
e = 1.6e-19 // charge on electron in coloumb
m_e = 9.1e-31 // mass of electron in kg
//Sample Problem 6 Page No. 137
printf("\n\n\n # Problem 6 # \n")
printf("\n Standard formula Used \n delta_lambda = h * (1 - cos (theta )) / ( m_e * c)")
delta_lambda = h * (1 - cos (theta )) /( m_e * c) // calculation of Change in wavelength of electron
printf("\n Change in wavelength of electron is %f Angstrom. ", delta_lambda*1e10)
```

**Scilab code Exa 3.7** Calculation of de Broglie wavelength of moving particle

```
clc
//Given that
angle = %pi/2 // scattering angle of photon
h = 6.624e-34 // plank's constant
v = 2e6 // speed of particle
e = 1.6e-19 // charge on electron
m = 1e-3 // mass of particle in kg
//Sample Problem 7 Page No. 137
printf("\n\n\n # Problem 7 # \n")
printf("\n Standard formula Used \n lambda = h / (m * v)")
lambda = h / (m * v) //calculation of de Broglie wavelength of particle
printf("\n de Broglie wavelength of particle is %e m.", lambda)
printf("\n Here the de Broglie wavelength is too small to be detected. This wavelength is far smaller than the wavelength of X ray.\n Hence diffraction experiment with such a stream of particle will not be successful.")
```

**Scilab code Exa 3.8.1** Determination of possibility of photo emission and velocity of photoelectron for nickel

```
clc
//Given that
lambda = 4.3e-7 // wavelength of light in meter
phi_Ni = 5 // work function of nickel in eV
h = 6.624e-34 // plank's constant
c = 3e8 // speed of light
```

```
m_e = 9.1e-31 // mass of electron in kg
//Sample Problem 8a Page No. 138
printf("\n\n\n # Problem 8a # \n")
lambda_threshold = h * c / (phi_Ni*1e-19) //
   calculation of longest wavelength required
if (lambda_threshold < lambda) then
    printf("\n As the threshold wavelength is less
       than wavelength of incident radiation \n So
       electron will not be ejected \n")
else
    v = sqrt((2* h * c *(lambda - lambda_threshold))
        / (m * lambda_threshold * lambda ))) //
       calculation of ejected velocity Electron
    printf("\n As the threshold wavelength is
       greater than wavelength of incident radiation
        So electron will be ejected with velocity %e
       . ",v)
end
```

**Scilab code Exa 3.8.2** Determination of possibility of photo emission and velocity of photoelectron for potassium

```
clc
//Given that
lambda = 4.3e-7 // wavelength of light in meter
phi_K = 2.3 // work function of nickel in eV
h = 6.624e-34 // plank's constant
c = 3e8 // speed of light
m_e = 9.1e-31 // mass of electron in kg
//Sample Problem 8b Page No. 138
printf("\n\n\n # Problem 8b # \n")
lambda_threshold = h * c / (phi_K *1.6e-19) //
   calculation of longest wavelength required
```

```
if (lambda_threshold < lambda) then
    printf("As the threshold wavelength is less than wavelength of incident radiation Solectron will not be ejected \n")
else
    v = sqrt((2* h * c *( lambda_threshold - lambda) ) / (m_e * lambda_threshold * lambda )) // calculation of ejected velocity Electron
    printf("\n As the threshold wavelength is greater than wavelength of incident radiation So \n electron will be ejected with velocity %e m/s. ",v)
end
```

**Scilab code Exa 3.9** Determination of wavelength for which the second order Bragg reflection occur at given angle

```
clc
//Given that
d = 3.04 // inter layer separation in Angstrom
theta = 14.7 // in degree
n = 2 // order of brags reflection
//Sample Problem  Page No. 139
printf("\n\n\n # Problem 9 # \n")
printf("\n Standard formula Used \n 2 * d * sin( theta) = n * lambda")
lambda = 2 * d * sin( theta * (%pi /180))/ n   // calculation of wavelength making second order Braggs reflection
printf ( " \n Second order brags reflection occurs at %f degree for the wavelength %f Angstrom\n" , theta , lambda)
```

**Scilab code Exa 3.10.1** Calculation of Inter atomic separation

```
clc
//Given that
lambda = 0.52 // wavelength in angstrom
theta = 5 // in degree
n = 1 // order of brags reflection
//Sample Problem 10 a  Page No. 139
printf("\n\n\n # Problem 10 a # \n")
printf("\n Standard formula Used \n 2 * d * sin(
    theta) = n * lambda ")
d = n * lambda / (2 * sin (theta * %pi / 180))
//calculation of separation between adjacent layers
    of crystals
printf ("\n Separation between adjacent layers of
    crystals is %f angstrom. ", d)
```

**Scilab code Exa 3.10.2** Calculation of angle for secondary maxima

```
clc
//Given that
n = 2 // order
lambda = 5.2e-11 // wavelength in Angstrom
d = 2.98e-10 // interatomic separation in Angstrom
//Sample Problem 10b page No. 139
printf("\n\n\n # Problem 10b # \n")
printf("\n Standard formula Used \n 2 * d * sin(
    theta) = n * lambda ")
```

```
theta_rad = asin ( (n * lambda) / ( 2 * d)) //
    calculation of angle for secondary maxima in
    radian
theta_deg = theta_rad * 180 / %pi //calculation of
    angle for secondary maxima in degree
printf ("\n Angle for secondary maxima is  %d. ",
    theta_deg )
```

**Scilab code Exa 3.11** Calculation of X ray frequency after scattering through 90 degree

```
clc
//Given that
nu = 3.2e19 // frequency in hartz
theta = 90 // angle of scattered photon in degree
m_e = 9.1e-31 // mass of electron in Kg
c = 3e8 // speed of light in m/s
h = 6.626e-34 // plank's constant
//Sample Problem 11  Page No. 140
printf("\n \n\n# Problem 11 # \n")
printf("\n Standard formula Used \n delta_lambda = h
     * (1 - cos (theta )) / ( m_e * c)")
lambda = c / nu//calculation of incident wavelength
lambda_shift = h *(1 - cos(theta * %pi / 180))/ (
    m_e * c) //calculation of shift in wavelength
lambda1 = lambda + lambda_shift//calculation of
    wavelength of scattered photon
nu1 = c / lambda1//calculation of Frequency after
    scattering
printf ("\n Frequency after scattering  is %e Hz. ",
     nu1)
```

**Scilab code Exa 3.12** Calculation of uncertainty inn momentum of electron if it is confined inside nucleus

```
clc
//Given that
r = 1e-14 // radius of nucleus of atom in meter
h = 6.626e-34 // Plank's constant
//Sample Problem 12 page No. 140
printf("\n\n\n # Problem 12 # \n")
printf("\n Standard formula Used \n delta_p * delta_x >= h /(2*pi)")
del_x = 2 * r //calculation of Uncertainty in position
del_p = h / (2 * %pi * del_x) //calculation of Uncertainty in momentum
printf ("\n Uncertainty in momentum is %e Kg-m/s. ", del_p )
```

---

**Scilab code Exa 3.13** Calculation of uncertainty in position of a moving electron

```
clc
//Given that
v = 300 // speed of electron in m/s
accuracy = 1e-4 // accuracy in speed
h = 6.6e-34 // Plank's constant
m_e = 9.1e-31 // mass of electron in Kg
//Sample Problem 13 page No. 140
```

```
printf("\n\n\n # Problem 13 # \n")
printf("\n Standard formula Used \n delta_p *
    delta_x >= h /(2*pi)")
del_p =  accuracy * m_e * v  //calculation of
    Uncertainty in  momentum
del_x = h / (4 * %pi * del_p)  //calculation of
    Uncertainty in position
printf ("\n Uncertainty in position of electron is
    %f mm. ", del_x*1000 )
```

**Scilab code Exa 3.14** Calculation of wavelength of first spectral line of Lyman series

```
clc
//Given that
lambda1 = 6560 // wavelength in Angstrom
n1 = 1 // transition state no
n2 = 2 // transition state no
n3 = 3 // transition state no.
//Sample Problem 14 page No. 141
printf("\n\n\n # Problem 14 # \n")
printf("\n Standard formula Used \n\n For Balmer
    Series \n 1/lambda =  R*(1-(1/n)^2) \n\n For
    Lyman series \n 1/lambda =  R*((1/2)^2 -(1/n)^2)"
    )
lambda2 = (n2^2 * n1^2) *(n3^2 - n2^2) /( (n2^2 - n1
    ^2) * (n3^2 * n2^2)) * lambda1  //calculation of
    Wavelength of first line of Lyman series
printf ("\n \nWavelength of first line of Lyman
    series is %f Angstrom. ", lambda2 )
```

**Scilab code Exa 3.15** Calculation of zero energy of a linear harmonic oscillator

```
clc
//Given that
m = 2e-3 // mass of linear harmonic oscillator in kg
k = 100 // spring constant in N/m
h = 6.6e-34 // Plank's constant
//Sample Problem 15 page No. 142
printf("\n\n\n # Problem 15 # \n")
printf("\n Standard formula Used \n f =  sqrt(k / m
   ) \n U = 1/2* h * nu ")
 nu = sqrt(k / m ) / (2 * %pi) //calculation of
    frequency of linear harmonic oscillator
U = 1/2* h * nu //calculation of Zero point energy
   of a linear harmonic oscillator
printf ("\n Zero point energy of a linear harmonic
   oscillator  is %e J.", U )
```

**Scilab code Exa 3.16.1** Calculation of wavelength of first spectral line of Lyman series

```
clc
//Given that
R = 1.097 // Rydberg s constant
n1 = 1 // transition state no
n2 = 2 // transition state no
//Sample Problem 16a page No. 142
```

```
printf("\n\n\n # Problem 16a # \n")
printf ("\n Standard formula Used \n For Lyman series 1/lambda = R*((1/2) ^2 - (1/n) ^2)")
nu1 = R * (n2^2 - n1^2) / (n1^2 * n2^2) // calculation of frequency of first line of Lyman series
lambda1 = 1/ nu1//calculation of Wavelength of first line of Lyman series
printf ("\n Wavelength of first line of Lyman series is %f Angstrom. ", lambda1 *1000)
```

**Scilab code Exa 3.16.2** Calculation of wavelength of second spectral line of Lyman series

```
clc
//Given that
R = 1.097 // Rydberg s constant
n1 = 1 // transition state no
n2 = 3 // transition state no
//Sample Problem 16b page No. 142
printf("\n\n\n # Problem 16b # \n")
printf("\n Standard formula Used \n For Lyman series 1/lambda =  R*((1/2)^2 -(1/n)^2)")
nu1 = R * (n2^2 - n1^2) / (n1^2 * n2^2) // calculation of frequency of first line of Lyman series
lambda1 = 1/ nu1 //calculation of Wavelength of first line of Lyman series
printf ("\n Wavelength of second line of Lyman series is %d Angstrom. ", lambda1 *1000 )
```

**Scilab code Exa 3.17** Calculation of temperature at which it will emit a wavelength with maximum energy

```
clc
//Given that
lambda1 = 4700 // wavelength in Angstrom
lambda2 = 1.4e-5//wavelength in cm
temp1 = 6174 // temperature of a black of in kelvin
//Sample Problem 17 page No. 143
printf("\n\n\n # Problem 17 # \n")
printf("\n Standard formula Used \n lambda * T =
    constant")
temp2 = lambda1 * temp1 / (lambda2 * 1e8) //
    calculation of temperature
printf ("\n Blackbody will emit  wavelength 1.4e-5
    cm at %d K.",  temp2 )
```

**Scilab code Exa 3.19.1** Calculation of Compton shift for 90 degree scattering

```
clc
//Given that
lambda = 1 // wavelength in Angstrom
theta = 90 // angle of scattered photon in degree
m_e = 9.11e-31 // mass of electron in Kg
c = 3e8 // speed of light in m/s
h = 6.63e-34 // plank's constant
//Sample Problem 19a page No. 144
```

```
printf("\n\n\n # Problem 19a # \n")
printf("\n Standard formula Used \n delta_lambda = h
    * (1 − cos (theta )) / ( m_e * c)")
lambda_shift = h *(1 - cos(theta * %pi / 180))/ (
   m_e * c) //calculation of Change in frequency
printf ("\n Change in frequency  is %f Hz. ",
   lambda_shift * 1e10)
```

**Scilab code Exa 3.19.2** Calculation of kinetic energy imparted to electron in Compton shift for 90 degree scattering

```
clc
//Given that
lambda1 = 1 // wavelength in Angstrom
lambda2 = 1.0243 // wavelength in Angstrom
c = 3e8 // speed of light in m/s
h = 6.63e-34 // plank's constant
//Sample Problem 19b page No. 144
printf("\n\n\n # Problem 19b # \n")
printf("\n Standard formula Used \n E= h *(nu1
   nu2)")
K = h * c * (( lambda2 - lambda1 )/ (lambda1 *
   lambda2 )) *(10e9 / 1.6e-19)   //calculation of
   Kinetic energy imparted to recoiling
printf ("\n Kinetic energy imparted to recoiling
   electron is %d eV.", K)
```

**Scilab code Exa 3.20** Calculation of final wavelength of scattered photon in Compton shift

```
clc
//Given that
theta = 90 // angle of scattered photon in degree
E_rest = 938.3 // rest mass energy of a proton in MeV
E = 12// energy of scattered proton in Mev
c = 3e8 // speed of light in m/s
h = 6.63e-34 // plank's constant
//Sample Problem 20 page No. 145
printf("\n\n\n # Problem 20 # \n")
printf("\n Standard formula Used \n delta_lambda = h * (1 - cos (theta )) / ( m_e * c)")
lambda = h * c / ( E * 1.6e-13) //calculation of incident wavelength
lambda1 = lambda + h * c / (E_rest * 1.6e-13)    //calculation of wavelength of scattered photon
printf ("\n wavelength of scattered photon is  %e Angstrom. ", lambda1 * 1e10)
```

---

**Scilab code Exa 3.21** Calculation of atomic number of unknown substance by Mosleys law

```
clc
//Given that
lambda1 = 1.321 // wavelength of L- alpha line for platinum
lambda2 = 4.174 // wavelength of l - alpha line of unknown substance
z1= 78// atomic number of platinum
c = 3e8 // speed of light in m/s
b = 7.4 // constant  for L - alpha line
//Sample Problem 21 page No. 146
printf("\n\n\n # Problem 21 # \n")
```

```
printf("\n Standard formula Used \n sqrt(nu1)= a*(Z-b)")
z2 = b + (z1 - b) * sqrt(lambda1 / lambda2) // calculation of the unknown substance has atomic number
printf ("\n The unknown substance has atomic number %d. ", z2)
```

**Scilab code Exa 3.22** Calculation of zero point energy in box of length of 1 angstrom

```
clc
//Given that
h = 6.6e-34 // plank's constant
m_e = 9.1e-31 // mass of electron in kg
L = 1e-10 // length of box of particle in m
//Sample Problem 22 page No. 146
printf("\n # Problem 22 # \n")
printf("\n Standard formula Used \n E= h^2 * (n_x^2+n_y^2+n_z^2) / (8*m*L^2)")
sum = 0
n_y = 1
    for n_x = 1:3

            for n_z = 1:2
                sum = n_x+n_y+n_z
                if sum<6 then
                    E = h^2 * (n_x^2+n_y^2+n_z^2)/(1.6e-19*8*m_e*L^2) // calculation of energy
                printf("\n \n E%d%d%d is  %f eV. ", n_x,n_y,n_z,E)
                end
```

```
          end
     end
```

# Chapter 4

# Frame of Reference

**Scilab code Exa 4.1** Calculation of magnitude of force vector and it angle with axes

```
clc
//Given that
F = [2.5,4.5,-5] // F is a force vector act through
    origin
// sample Problem 1  Page No. 176
printf("\n\n\n # Problem 1 # \n")
F_magnitude = sqrt ( 2.5^2 + 4.5^2 + (-5)^2)
theta_x = (180 / %pi ) * acos ( 2.5 / F_magnitude)
theta_y = (180 / %pi ) * acos ( 4.5 / F_magnitude)
theta_z = (180 / %pi ) * acos ( -5 / F_magnitude)
printf (" \n Magnitude of force F is %f N",
    F_magnitude)
printf(" \n Angle made with X - axis is %f degree",
    theta_x)
printf(" \n Angle made with Y - axis is %f degree" ,
    theta_y)
printf(" \n Angle made with Z - axis is %f degree",
    theta_z)
```

**Scilab code Exa 4.2.1** To determine directional cosines of force vector

```
clc
//Given that
r = [2,2,2*sqrt(2)]

// sample Problem 2a  Page No. 176
printf("\n \n\n # Problem 2a # \n")
r_magnitude = sqrt ( 2^2 + 2^2 + (2*sqrt(2))^2)
cos_x =  ( 2 / r_magnitude)
cos_y = ( 2 / r_magnitude)
cos_z = ( 2.8284 / r_magnitude)
printf(" \n Directional cosine in X - axis is %f ", cos_x)
printf(" \n Directional cosine in Y - axis is %f " , cos_y)
printf(" \n Directional cosine in Z - axis is %f ", cos_z)
```

**Scilab code Exa 4.2.2** To determine projection of a vector in xz and yz planes

```
clc
//Given that
r_xz = [2,2.8282]
// sample Problem 2b  Page No. 176
printf("\n \n\n # Problem 2b # \n")
```

```
r_xz = sqrt (2^2 + (2.8282)^2)
r_yz = sqrt (2^2 + (2.8282)^2)
printf (" \n Projection of vector r in xz plane is
   %f", r_xz)
printf (" \n projection of vector r in yz plane is
   %f", r_yz)
```

**Scilab code Exa 4.3** Determination of work done by three forces

```
clc
//Given that
d1 = [5,-5,-4] // initial coordinate point of vector
    d
d2 = [6,2,-2] // final coordinate point of vector d
F1 = [10,-1,10] // first force acting on particle
F2 = [4,5,6] // second force acting on particle
F3 = [-2,1,-9]  // third force acting on particle


// sample Problem 3  Page No. 177
printf("\n \n\n # Problem 3 # \n")
d = d2 - d1 // d is vector of displacement
F = F1 + F2 + F3 // F is resultant of all the force
printf("Standard formula used is W = F*d \n ")
W = F * d'
printf(" \n Total work done  is %d units ", W)
```

**Scilab code Exa 4.4** Determination of vector to make airplane landing in time

```
clc
//Given that
v_w_x = 40 * cos(45 * %pi / 180) // x component of
    wind blow in miles/h
v_w_y = 40 * sin(45 * %pi /180) // y component of
    wind blow in miles/h
r_x = 200 // distance  of destination point in x
    direction in miles
r_y = 0 // distance  of destination point in y
    direction in miles
t = 40 // time taken by aeroplane to reach
    destination in minutes
// sample Problem 4  Page No. 177
printf("\n # Problem 4 # \n")
printf("Standard formula used is V = V1 + V2 +
    .....+ V_n \n ")
v_x = (r_x)/t *60 // x - component of velocity
    required to reach destination in time in miles/h
v_y = r_y /t *60 // x - component of velocity
    required to reach destination in time in miles/h
v_p_x = v_x - v_w_x // x component of aeroplane
    velocity in miles/h
v_p_y = v_y - v_w_y // y component of aeroplane
    velocity in miles/h
printf(" \n Vector of velocity of pilot with respect
     to moving air is %f i %fj miles/h \n where i and
     j stands for east and north respectively ",
    v_p_x,v_p_y)
```

**Scilab code Exa 4.5** Determination of difference in acceleration due to gravity at pole and equator

```
clc
```

```
//Given that
R_e = 6.4e6 // radius of earth in m
T = 8.64e4 // time period of one rotation of earth
theta_pole = 90 // angle between pole and rotational
    axis
theta_equator = 0 // angle between equator and
   rotational axis
g_pole = 9.8 // gravitational acceleration at pole
   in m/s^2
// sample Problem 5 Page No. 178
printf ("\n \n\n # Problem 5 # \n")
printf("Standard formula used is g1 = g - R_e*f^2*(
   cos(theta))^2 \n ")
f = 2 * %pi / T // rotational frequency of earth
 g_equator = g_pole -  R_e * f^2
 del_g = g_pole - g_equator
printf(" \n Difference in gravitational acceleration
    at pole and equator is %e m/s^2 ", del_g)
```

**Scilab code Exa 4.6** Determination of angular velocity of earth if acceleration due to gravity at pole is zero and length of day

```
clc
//Given that
R_e = 6.4e6 // radius of earth in m
theta_pole = 90 // angle between pole and rotational
    axis
theta_equator = 0 // angle between equator and
   rotational axis
g_pole = 10 // gravitational acceleration at pole in
    m/s^2
g_equator = 0 // gravitational acceleration at
   equator in m/s^2
```

```
// sample Problem 6 Page No. 178
printf ("\n \n\n # Problem 6 # \n")
printf("Standard formula used is g1 = g - R_e*f^2*(
    cos(theta))^2 \n ")
 f = sqrt (g_pole / R_e)
 T = 2 * %pi / f / 3.6e3
 printf("Angular velocity of Earth will be %e rad/s
     \n Time period would be %f hours",f,T)
```

**Scilab code Exa 4.7** Determination of angular velocity of earth if acceleration due to gravity becomes three fourth of its initial value

```
clc
//Given that
g_pole = 9.8 // gravitational acceleration at pole
m = 1 // mass of substance in kg
R_e = 6.4e6 // radius of earth in m
// sample Problem 7  Page No. 179
printf("\n  # Problem 7 # \n")
printf("Standard formula used is \n coriolis force =
     -2*m*f x v\n \n")
 g_equator = 0.75 *g_pole // gravitational
     acceleration at equator in m/s^2
  f = sqrt ((g_pole - g_equator)/ R_e)
 printf ("Angular velocity of Earth will be %e rad/s
      .\n ",f)
```

**Scilab code Exa 4.8** Determination of magnitude and direction of Carioles force acting on mass

```
clc
//Given that
m = 1 // mass of particle in kg
theta = 30 // latitude position in degree
v = 0.5 // velocity of particle in km/s in north direction


// sample Problem 8  Page No. 180
printf("\n # Problem 8 # \n")
printf("Standard formula used is coriolis Force = 2*mass*angular velocity X velocity ")
f_x = -2*m*2*%pi * v*1000*(-1)*sin(theta*%pi/180)/86400 // coriolis force in east direction
f_z = -2*m*2*%pi * v*1000*cos(theta*%pi/180)/86400 // coriolis force in verticle direction
F = sqrt(f_x^2+f_z^2)
alpha = -atan(f_z/f_x) *180 /%pi
printf(" \n Magnitude and direction  of coriolis force on particle are \n %e N and %d degree with east respectively",F,alpha)
```

# Chapter 6

# Relativistic Kinematics and Paradoxes in Relativity

**Scilab code Exa 6.1** Calculation in percentage contraction in length moving with speed and with inclination of 60 degree

```
clc
//Given that
c = 3e8 // speed of light in m/s
v = 0.8* c // velocity of rod
l1 = 1 // let
theta = 60 // anlge between length of rod and speed
   in degree
//Sample Problem 1 page No. 221
printf("\n # Problem 1 # \n")
l_x = l1 * cos(theta * %pi /180) * sqrt (1-(v /c)^2)
l_y = l1 * sin(theta * %pi /180)
l2 = sqrt (l_x^2 + l_y^2)
per_contrtaction = (l1 - l2) / l1 *100
angle = atan (l_y/l_x)
printf ("Percentage contraction in rod is %f and
   apparant orientation is %f",per_contrtaction,tan
```

```
(angle) )
```

**Scilab code Exa 6.2** Determination of relative velocity between two photons approaching towards each other

```
clc
//Given that
c = 3e8 // speed of light in m/s
u_x_ = -3e8 // velocity of first photon in ground frame in m/s
v = -3e8 // velocity of second photon in ground frame in m/s
// sample problem 2 page No. 222
printf("\n \n\n # Problem 2 # \n")
printf("\n Standard formula used is  u_x = (u_x_ + v) / (1 + v * u_x_ / c^2) ")
u_x = (u_x_ + v) / (1 + v * u_x_ / c^2) // calculation of Velocity of photon with respect to another
printf ("\n Velocity of photon with respect to another is %d * c \n Thus photons are approaching each other.",u_x / c)
```

**Scilab code Exa 6.3** Determination of relative velocity between two spaceship approaching towards each other with velocity

```
clc
//Given that
c = 3e8 // speed of light in m/s
```

```
u_x_ = -0.9 * c // velocity of first spaceship in ground frame in m/s
v = -0.9 *c // velocity of second spaceship in ground frame in m/s
// sample problem 3 page No. 222
printf("\n \n\n # Problem 3 # \n")
printf("\n Standard formula used is  u_x = (u_x_ + v) / (1 + v * u_x_ / c^2) ")
u_x = (u_x_ + v) / (1 + v * u_x_ / c^2) // calculation of Velocity of photon
printf ("\n Velocity of photon with respect to another is %f c.", u_x / c)
```

**Scilab code Exa 6.4** Determination of mass consumed to obtain energy

```
clc
//Given that
E = 7.5e11 // Energy in kWh
c = 3e8 // speed of light in m/s
// sample problem 4 page No. 223
printf("\n \n\n # Problem 4 # \n")
printf("\n Standard formula used \n E = m*c^2")
m = (E *3.6e6) / c^2// calculation of Amount of mass consumed

printf ("\n Amount of mass consumed is %d kg.", m)
```

**Scilab code Exa 6.5** Determination of energy that can be produced by consumption of 4 kg of mass

```
clc
//Given that
m = 4 // mass of substance consumed fully in kg
c = 3e8 // speed of light in m/s
// sample problem 5 page No. 223
printf("\n \n\n # Problem 5 # \n")
printf("\n Standard formula used \n E = m*c^2")
E = m * c^2// calculation of Amount of energy produced
printf ("\n Amount of energy produced is %e J.", E)
```

**Scilab code Exa 6.6** Calculation of relativistic mass

```
clc
//Given that
m_0 = 1e-24 // mass of moving particle in kg
v = 1.8e8 // speed of particle in m/s
c = 3e8 // speed of light in m/s
// sample problem 6 page No. 223
printf("\n \n\n # Problem 6 # \n")
printf("\n Standard formula used \n m = m_o/ sqrt (1- (v/c)^2)")
m = m_0 / sqrt(1 - (v / c)^2) // calculation of Relativistic mass of particle
printf ("\n Relativistic mass of particle is %e kg.", m)
```

**Scilab code Exa 6.7** Determination of ratio of rest mass and relativistic mass of a moving particle

```
clc
//Given that
c = 3e8 // speed of light in m/s
v = 0.5 * c // speed of particle in m/s
// sample problem 7 page No. 223
printf("\n \n\n # Problem 7 # \n")
printf("\n Standard formula used \n m = m_o/sqrt (
   1- (v/c)^2)")
ratio = sqrt(1- (v /c)^2) // calculation of Ratio of
    rest mass and relativistic mass of particle
printf ("\n Ratio of rest mass and relativistic mass
    of particle is %f.", ratio)
```

**Scilab code Exa 6.8.1** Determination of speed of space ship if observed length is half of original length

```
clc
//Given that
ratio = 0.5 // Ratio of lengths of spaceship
c = 3e8 // speed of light in m/s
// sample problem 8a page No. 224
printf("\n \n\n # Problem 8a # \n")
printf("\n Standard formula used \n l = l_o* sqrt (
   1- (v/c)^2)")
v = c * sqrt(1 - ratio^2) // calculation of Speed of
    spaceship
printf ("\n Speed of spaceship is %e m/s.",v)
```

**Scilab code Exa 6.8.2** Determination of time dilation if observed length is half of original length

```
clc
//Given that
c = 3e8 // speed of light in m/s
v = 2.598e8 // speed of spaceship
t_0 = 1 // time in second
// sample problem 8b page No. 224
printf("\n \n\n # Problem 8b # \n")
printf("\n Standard formula used \n t= t_o/ sqrt (
   1- (v/c)^2)")
t = t_0 / sqrt(1 - (v ^2 / c ^2) ) // calculation of
    Time corresponding to 1 sec
printf ("\n Time corresponding to 1 sec is %d sec.",
   ceil (t) )
```

**Scilab code Exa 6.9** Calculation of mean life of meson moving with velocity

```

clc
//Given that
c = 3e8 // speed of light in m/s
v = 2.4e8 // speed of meson
t_0 = 2e-8 // lifetime of meson in second
// sample problem 9 page No. 224
printf("\n \n\n # Problem 9 # \n")
printf("\n Standard formula used ")
t = t_0 / sqrt(1 - (v  / c )^2 ) // calculation of
   Lifetime of meson
printf ("\n Lifetime of meson is %e sec.", t )
```

**Scilab code Exa 6.10** Determination of velocity of 1 amu mass if it has kinetic energy twice of its rest mass

```
clc
//Given that
c = 3e8 // speed of light in m/s
m_0 = 1 // atomic mass in amu
m = 3 * m_0 // relativistic mass
// sample problem 10 page No. 225
printf("\n \n\n # Problem 10 # \n")
printf("\n Standard formula used  l = l_o * sqrt (
   1- (v/c)^2)")
v = c * sqrt(1- (m_0 / m)^2) // calculation of
   Velocity of particle
printf ("\n Velocity of particle is %f c.", v / c )
```

---

**Scilab code Exa 6.11** Determination of velocity of a mass if it has total energy twice of its rest mass

```
clc
//Given that
mass_ratio = 0.5 // Ratio of rest mass and
   relativistic mass
c = 3e8 // speed of light in m/s
// sample problem 11 page No. 225
printf("\n # Problem 11 # \n")
printf("\n Standard formula used \n m = m_o / sqrt (
    1- (v/c)^2)\n")
```

```
v = c * sqrt(1- mass_ratio^2) // calculation of
    Velocity of particle
printf ("\n Velocity of particle is %f c.", v / c )
```

**Scilab code Exa 6.12.1** Determination of relativistic mass velocity observed by one mass for other

```
clc
//Given that
c = 3e8 // speed of light in m/s
u_x_ = -2e8 // velocity of first photon in ground
    frame in m/s
v = -2e8 // velocity of second photon in ground
    frame in m/s
m_0 = 3e-25
// sample problem 12 page No. 226
printf("\n \n\n # Problem 12a # \n")
printf("\n Standard formula used \n u_x = (u_x_ + v)
     / (1 + v * u_x_ / c^2)")
u_x = (u_x_ + v) / (1 + v * u_x_ / c^2) //
    calculation of Velocity of photon with respect to
     another
m = m_0 / sqrt(1 - (u_x / c)^2) // calculation of
    Relativistic mass of particle with respect to
    another
printf ("\n Velocity of photon with respect to
    another is %e m/s.",u_x)
printf ("\n Relativistic mass of particle with
    respect to another is %e kg.",m)
```

**Scilab code Exa 6.12.2** Determination of relativistic mass observed by one mass for other

```
clc
//Given that
c = 3e8 // speed of light in m/s
ratio = 1.95e+03 // Ratio of relativistic mass and
    rest mass
// sample problem 14b page No. 227
printf("\n \n\n # Problem 14b # \n")
printf("\n Standard formula used \n m = m_o/ sqrt (
    1- (v/c)^2)")
ratio_1 = 1 /(2* ratio^2)     // calculation of ratio
     of velocity to velocity of light for
printf ("\n Ratio of velocity to velocity of light
    for particle is 1 -  %e .", ratio_1 )
```

---

**Scilab code Exa 6.13** Determination of observed density of gold if it is moving with speed having density

```
clc
//Given that
c = 3e8 // speed of light in m/s
u = 0.9*c // velocity of first particle with respect
     to other in m/s
density1 = 19.3e-3 // density of gold in rest frame
// sample problem 13 page No. 226
printf("\n \n\n # Problem 13 # \n")
```

```
printf("\n Standard formula used \n m = m_o/ sqrt (
    1- (v/c)^2) \n and \n l = l_o* sqrt ( 1- (v/c)^2)
    ")
mass_ratio = sqrt (1 - (u/c)^2) // calculation of
    ratio of relativistic mass
volume_ratio = 1 / sqrt (1 - (u/ c)^2) //
    calculation of ratio of relativistic volume
density2 = density1 * (volume_ratio /mass_ratio ) //
    calculation of ratio of relativistic density
printf ("\n Relativistic density of rod in moving
    frame is %e.",density2)
```

**Scilab code Exa 6.14.1** Determination of ratio of relativistic mass to rest mass

```
clc
//Given that
E = 1e9 // energy of electron in eV
c = 3e8 // speed of light in m/s
m_0 = 9.1e-31 // mass of electron in kg
// sample problem 14 page No. 227
printf("\n \n\n # Problem 14a # \n")
printf("\n Standard formula used  \n E = m*c^2")
m = E / c^2 * 1.6e-19      // calculation of
    relativistic mass of particle
ratio = m / m_0// calculation of Ratio of
    relativistic mass and rest mass of particle
printf ("\n Ratio of relativistic mass and rest mass
      of particle is %e.",ratio )
```

**Scilab code Exa 6.14.2** Determination of ratio of velocity of electron with respect to speed of light

```
clc
//Given that
c = 3e8 // speed of light in m/s
ratio = 1.95e+03 // Ratio of relativistic mass and
   rest mass
// sample problem 14b page No. 227
printf("\n \n\n # Problem 14b # \n")
printf("\n Standard formula used \n m = m_o/ sqrt (
   1- (v/c)^2)")
ratio_1 = 1 /(2* ratio^2)    // calculation of ratio
    of velocity to velocity of light for
printf ("\n Ratio of velocity to velocity of light
   for particle is 1 -  %e .", ratio_1 )
```

---

**Scilab code Exa 6.14.3** Determination of ratio of their energy to rest mass energy

```
clc
//Given that
m = 9e-31 // mass in kg
E = 1e9 // Energy of accelerated electron in eV
c = 3e8 // speed of light in m/s
// sample problem 14c page No. 227
printf("\n \n\n # Problem 14c # \n")
printf("\n Standard formula used \n E = m*c^2")
```

```
E_0 = m * c^2// calculation of rest mass energy
ratio = E / E_0 *1.6e-19// calculation of Ratio of
    energy to rest mass energy
printf ("\n Ratio of energy to rest mass energy is
    %e.",ratio )
```

**Scilab code Exa 6.15** Determination of proper length of rod if observed length is 1 m and moving with velocity

```
clc
//Given that
c = 3e8 // speed of light in m/s
v = 0.6 * c // velocity of rod wrt laboratory
l_ = 1 // length of rod measured by observer in lab
// sample problem 15 page No. 228
printf("\n \n\n # Problem 15 # \n")
printf("\n Standard formula used \n l = l_o* sqrt (
    1- (v/c)^2)")
l = l_ / sqrt (1 - (v / c)^2)  // calculation of
    Proper length of rod
printf ("\n Proper length of rod  is %f m.",l )
```

**Scilab code Exa 6.16** Determination of mean life of meson traveling with velocity

```
clc
//Given that
c = 3e8 // speed of light in m/s
v = 0.9 * c // velocity of rod wrt laboratory
```

```
proper_time = 2.5e-8 // proper mean life time of mesons
// sample problem 16 page No. 228
printf("\n \n\n # Problem 16 # \n")
printf("\n Standard formula used \n t = t_o /sqrt (1- (v/c)^2)")
t = proper_time / sqrt (1 - (v / c)^2) // calculation of New mean life time
printf ("\n New mean life time is %e s.",t )
```

**Scilab code Exa 6.17** Determination of velocity of electron having relativistic energy of 1MeV

```
clc
//Given that
E = 1 // energy of electron in MeV
c = 3e8 // speed of light in m/s
m_0 = 9e-31 // rest mass of electron
// sample problem 17 page No. 229
printf("\n \n\n # Problem 17 # \n")
printf("\n Standard formula used \n m = m_o* sqrt (1- (v/c)^2) \n and \n E=m*c^2")
m = E * 1.6e-13 / c^2// calculation of mass of electron
v = c * sqrt(1 - (m_0 / m)^2) // calculation of Velocity of electron
printf ("\n Velocity of electron is %e m/s.",v )
```

**Scilab code Exa 6.19** Calculation of distance travelled by meson

```
clc
//Given that
c = 3e8 // speed of light in m/s
v = 0.99 * c  // velocity of particle
proper_time = 2.2e-6 // proper mean life time of
    mesons
// sample problem 19 page No. 230
printf("\n \n\n # Problem 19 # \n")
printf("\n Standard formula used \n t = t_o /sqrt (
    1- (v/c)^2)")
t = proper_time / sqrt (1 - (v / c)^2) //
    calculation of time period
d = v *t// calculation of Distance travelled by
    particle
printf ("\n Distance traveled by particle is %e m.",
    d )
```

---

**Scilab code Exa 6.20** Determination of speed if mass is increased by 1 percet

```
clc
//Given that
c = 3e8 // speed of light in m/s
m = 1 // let
m_change = 1 // change in mass in percentage by
    increasing velocity
// sample problem 20 page No. 230
printf("\n \n\n # Problem 20 # \n")
printf("\n Standard formula used \n m = m_o* sqrt (
    1- (v/c)^2) ")
v = c * sqrt (1 - (m / (m + m_change/100))^2) //
    calculation of Velocity required to increase mass
     by one percent
```

```
printf ( "\n Velocity required to increase mass by one perfect is %e m/s.", v)
```

**Scilab code Exa 6.21** Determination of speed if mass is increased by 2000 times

```
clc
//Given that
c = 3e8 // speed of light in m/s
m_ratio = 2000 // ratio of rest mass and relativistic mass
// sample problem 21 page No. 231
printf("\n \n\n # Problem 21 # \n")
printf("\n Standard formula used \n m = m_o* sqrt (1- (v/c)^2) ")
v = c * sqrt (1 - (1/m_ratio)^2) // calculation of Velocity required to increase mass by 2000 times

printf( "\n Velocity required to increase mass by 2000 times is %e - %f m/s.",c, (c -v))
```

**Scilab code Exa 6.22** Determination of energy of each particle produced in pair production by photon

```
clc
//Given that
h = 6.63e-34 // plank's constant
c = 3e8 // speed of light in m/s
lambda = 5e-4 // wavelength of photon in angstrom
```

```
e_rest_mass = 0.511 // rest mass of electron in Mev/
    c^2
p_rest_mass = 0.511 // rest mass of electron in Mev/
    c^2
// sample problem 22 page No. 230
printf("\n \n\n # Problem 22 # \n")
printf("\n Standard formula used \n E_total = E_rest
    + E_kinetic")
k = (((h * c  / (lambda * 1.6e-23 ))  - (e_rest_mass
    + p_rest_mass))) /2 // calculation of Energy of
    each particle
printf( "\n Energy of each particle is  %f MeV.", k
    )
```

**Scilab code Exa 6.23** Determination of threshold wavelength for proton antiproton pair production

```
clc
//Given that
h = 6.63e-34 // plank's constant
c = 3e8 // speed of light in m/s
p_rest_mass = 938 // rest mass of proton in Mev/
ap_rest_mass = 938 // rest mass of antiproton in Mev
// sample problem 23 page No. 232
printf("\n \n\n # Problem 23 # \n")
printf("\n Standard formula used \n E = h* c /
    lambda")
lambda = h * c / ((p_rest_mass + ap_rest_mass) * 1.6
    e-19) // calculation of Threshold wavelength for
     proton - antiproton production
printf( "\n Threshold wavelength for proton -
    antiproton production is  %f angstrom.", lambda /
     1e-10)
```

**Scilab code Exa 6.24** Determination of momentum of proton having kinetic energy 1Bev

```
clc
//Given that
c = 3e8 // speed of light in m/s
p_rest_mass = 0.938 // rest mass energy of proton in
    BeV
KE = 1 // kinetic energy of proton in BeV
// sample problem 24 page No. 232
printf("\n \n\n # Problem 24 # \n")
printf("\n Standard formula used E^2 = p^2*c^2 + m_o
    ^2*c^4*")
E = KE + p_rest_mass// calculation of energy of
    particle
p = (sqrt (E^2 *1e6 - (p_rest_mass * 1e3)^2)) *(1.6e
    -19)*(1e9) / c// calculation of Momentum of
    photon
printf( "\n Momentum of photon is %e kg m/s.", p)
```

**Scilab code Exa 6.26** Determination of speed of meson

```
clc
//Given that
c = 3e8 // speed of light in m/s
t = 8e-6 // mean life of meson
l = 10 // distance of meson from earth surface
```

```
// sample problem 26 page No. 228
printf("\n \n\n # Problem 26 # \n")
printf("\n Standard formula used \n l = l_o* sqrt (1- (v/c)^2)")
v = l*1e3/ sqrt( t^2 +(l * 1e3 /c)^2) // calculation of relative speed of meson with respect to
printf ("\n Relative speed of meson with respect to earth  is %f c .",v/c )
```

**Scilab code Exa 6.27** Calculation of kinetic energy of a proton with velocity

```
clc
//Given that
c = 3e8 // speed of light in m/s
v = 0.8 *c // velocity of rod in m/s
m_0 = 1.673e-27 // rest mass of proton in kg
// sample problem 27 page No. 228
printf("\n \n\n # Problem 27 # \n")
printf("\n Standard formula used \n E_total = KE + E_mass")
K_E = m_0 * c^2 *(1/sqrt(1-(v/c)^2) - 1) / 1.6e-13 // calculation of Kinetic energy of proton
printf ("\n Kinetic energy of proton is %dMeV.", K_E )
```

# Chapter 8

# Our Solar System

**Scilab code Exa 8.4.1** Comparison of speeds of two satellites

```
clc
//Given that
t1 = 1 // time period of satellite s1 in hours
t2 = 8 // time period of satellite s2 in hour
r1 = 1.2e4 // radius of orbit of satellite s1 in km

// sample problem 4a page No. 300
printf("\n\n\n # Problem 4a # \n")

printf("Standard formula r2/r1 = (t2/t1)^(2/3)")
r2 = r1 * (t2/t1)^(2/3) // calculation of radius of
    orbit of satellite s2 in km
v1 = 2 * %pi * r1 / t1  // calculation of speed of
    satellite s1 in km/h
v2 = 2 * %pi * r2 / t2  // calculation of speed of
    satellite s2 in km/h
del_v = v2 - v1 // calculation of relative speed of
    satellites in km/h

```

```
printf (" \n Relative speed of satellite s2 wrt
    satellite s1 is %e km/h.", del_v)
```

**Scilab code Exa 8.4.2** Comparison of angular speeds of two satellites

```
clc
//Given that
t1 = 1 // time period of satellite s1 in hour
t2 = 8 // time period of satellite s2 in hour
r1 = 1.2e4 // radius of orbit of satellite s1 in km

// sample problem 4b page No. 300
printf("\n\n\n # Problem 4b # \n")

printf("Standard formula r2/r1 = (t2/t1)^(2/3)")
r2 = r1 * (t2/t1)^(2/3) // calculation of radius of
    orbit of satellite s2 in km
v1 = 2 * %pi * r1 / t1 // calculation of speed of
    satellite s1 in km/h
v2 = 2 * %pi * r2 / t2 // calculation of speed of
    satellite s2 in km/h
del_v = v2 - v1 // calculation of relative speed of
    satellites in km/h
del_r = r2 - r1 // calculation of closest distance
    between satellite s1 and s2
v_angular = del_v / del_r // calculation of angular
    speed in rad/h
printf (" \n Relative angular speed of satellite s2
    for satellite s1 is %e rad/h.", v_angular)
```

**Scilab code Exa 8.5** Calculation of orbital velocity and period of revolution of satellite

```
clc
//Given that
h = 2620 // distance of satellite from surface of
   Earth in km
R_e = 6400 // radius of Earth in km
M_e = 6e24 // mass of Earth in kg
G = 6.67e-11 // universal gravitational constant

// sample problem 5 page No. 300
printf("\n\n\n # Problem 5 # \n")

printf("Standard formula used \n\t v_o = sqrt(G*M_e/
   r) \n ")
printf("\n \t T = 2 * pi * r / v_o \n ")
r = R_e + h
v_o = sqrt(G * M_e / (r * 1e3))
T = 2 * %pi * r*1000 / (v_o*3600)
printf ("\n Orbital velocity of satellite is %f km/s
    \n period of revolution is %f h.",v_o / 1000, T)
```

**Scilab code Exa 8.6** Calculation of orbital velocity and period of revolution of satellite

```
clc
//Given that
```

```
h = 3e5 // distance of satellite from surface of
    Earth in m
R_e = 6.38e6 // radius of Earth in km
M_e = 6e24 // mass of Earth in kg
g = 9.8 // gravitational acceleration in m/s2

// sample problem 6 page No. 301
printf("\n\n\n # Problem 6 # \n")

printf("Standard formula used v_o = sqrt(G*M_e/r) \n
    ")
printf("Standard formula used T = 2 * pi * r / v_o \
    n ")
r = R_e + h// calculation of effective distance
    between Earth and satellite

G = g * R_e^2 / M_e// calculation of gravitational
    constant
v_o = sqrt(G * M_e / r) / 1000// calculation of
    orbital velocity of satellite
T = 2 * %pi * r / (v_o * 1000) / 3.6e3 //
    calculation of period of revolution of satellite

printf ("\n Orbital velocity of satellite is %f km/s
    \n period of revolution is %f h.",v_o, T)
```

**Scilab code Exa 8.7** Estimation of mass of Earth

```
clc
//Given that
t = 27.3 // period of lunar orbit around Earth in
    days
r = 3.9e5 // distance of satellite from Earth in km
```

```
G = 6.67e-11 // universal gravitational constant
// sample problem 7 page No. 301
printf("\n # Problem 7 # \n")
printf("Standard formula used \n T = 2 * pi * sqrt ((r^3)/G*M_e) \n ")
T = t * 24 * 60 * 60// calculation of time in seconds
M_e = 4 * %pi^2 * (r * 1000)^3 / (G * T^2) // calculation of mass of Earth
printf ("\n Estimated mass of Earth is %e kg.", M_e)
```

**Scilab code Exa 8.8** Estimation of mass of sun

```
clc
//Given that
t = 1 // period of  Earth's revolution around Sun in years
r = 1.5e8 // distance between Sun and Earth in km
G = 6.67e-11 // Universal gravitational constant
// sample problem 8 page No. 302
printf("\n\n\n # Problem 8 # \n")
printf("Standard formula used T = 2 * pi * sqrt ((r^3)/G*M_e) \n ")
T = t * 24 * 60 * 60 *356// calculation of time period in seconds
M_s = 4 * %pi^2 * (r * 1000)^3 / (G * T^2) // calculation of mass of Sun
printf ("\n Estimated mass of Sun is %e kg.", M_s)
```

**Scilab code Exa 8.9** Determination of height achieved by Rocket

```
clc
//Given that
R_e = 6.4e6 // radius of Earth in km
M_e = 6e24 // mass of Earth in kg
G = 6.67e-11 // universal gravitational constant
u = 6e3 // initial speed of rocket in m/s

// sample problem 9 page No. 302
printf("\n\n\n # Problem 9 # \n")

printf("Standard formula used U_f - U_i = 1/2 * m *(u^2 - v^2)\n ")
h = ((R_e * 1e3)^2 * u^2) / (2 * G * M_e - R_e * u^2) / 1000    // calculation of Height reached by rocket before returning to Earth

printf ("\n Height reached by rocket before returning is %e km.",h)
```

**Scilab code Exa 8.10** Determination of velocity to be given to mass to achieve a particular height

```
clc
//Given that
R_e = 6.4e6 // radius of Earth in km
M_e = 6e24 // mass of Earth in kg
G = 6.67e-11 // universal gravitational constant
// sample problem 10 page No. 303
printf("\n\n\n # Problem 10 # \n")

printf("Standard formula used U_f - U_i = 1/2 * m *(
```

```
u^2 - v^2)\n ")
h = 10 * R_e
v = sqrt (2 *h * G * M_e / (R_e * h))  //calculation of velocity required by mass to reach given height
printf ("\n Velocity required by mass is %e m/s.",v)
```

**Scilab code Exa 8.11** Comparison of time period and speed of two planets

```
clc
//Given that
r1 = 1e12 // distance of first planet from Sun in m
r2 = 1e13 //distance of first planet from Sun in m
// sample problem 11 page No. 304
printf("\n\n\n # Problem 11 # \n")

printf("Standard formula used T^2 = k* r^3")
printf ("\n Standers formula used v = 2 * pi * r / T ")
r_ratio = r1 / r2 // r_ratio is ratio of distances from Sun
T_ratio = r_ratio^(3/2) //calculation of Ratio of time period
v_ratio = r_ratio / T_ratio // calculation of ratio of speed

printf (" \n Ratio of time period is %f and ratio of speed is %f .", T_ratio, v_ratio)
```

**Scilab code Exa 8.12** Estimation of separation of Saturn from Sun

```
clc
//Given that
r1 = 1.5e8 // distance of Earth from Sun in km
t1 = 1 // let
// sample problem 12 page No. 305
printf ("\n\n\n # Problem 12 # \n")

printf ("\n Standard formula used T^2 = k* r^3")
t2 = 29.5 * t1// calculation of time period of Saturn
r2 = r1 * (t2 / t1) ^ (2/3) //calculation of distance of stern from Sun

printf (" \n Distance of Saturn from Sun is %e km ." , r2)
```

---

**Scilab code Exa 8.13** Determination of speed of a satellite at perigee and apogee

```
clc
//Given that
r_peri = 360 // distance of perigee of satellite from Earth surface in km
r_apo = 2500 // distance of apogee of satellite from Earth surface in km
R_e = 6400 // radius of Earth in km
v_p = 30000 // speed of satellite at apogee position in km/h
// sample problem 13 page No. 305
printf ("\n\n\n # Problem 13 # \n")

```

```
printf ("\n Standard formula used v * r = k ")
r_p = r_peri + R_e // calculation of distance of perigee
r_a = r_apo + R_e// calculation of distance of apogee

v_a = v_p * r_p / r_a // calculation of speed at apogee
printf (" \n Speed at perigee is %d km/h and at apogee is %f km/h .",v_p, v_a)
```

**Scilab code Exa 8.14** Calculation of impulse magnitude and its direction required to put satellite into orbit

```
clc
//Given that
h = 600 // distance of satellite from surface of Earth in km
R_e = 6400 // radius of Earth in km
m_s = 100  // mass of satellite in kg
g = 10 // gravitational acceleration in m/s2
v_y = 2500 // upward velocity of launched satellite
// sample problem 14 page No. 306
printf("\n\n\n # Problem 14 # \n")

printf("\n Standard formula used 1/2 *(m_s * v ^2 / r) = g * R_E^2 * m /R_e^2 ")
r = R_e + h// calculation of effective height of satellite

v = sqrt (g * (R_e * 1e3)^2 / (r * 1e3)) // calculation of orbital velocity of satellite

```

```
P_x = m_s * v// calculation of momentum in x
    direction
P_y = m_s * v_y// calculation of momentum in y
    direction
U = sqrt(P_x^2 + P_y^2 ) // calculation of magnitude
     of impulse required

theta = (180 / %pi) * atan (P_y / P_x ) //
    calculation of direction of impulse required
printf ("\n Magnitude and direction of impulse
    required are respectively %ekgm/s and %f degree."
    ,U , theta)
```

**Scilab code Exa 8.15.1** Calculation of loss of mass in the formation of 1 atom of hydrogen

```
clc

//Given that
b_e = 13.6 // Binding energy of electron to proton
    in eV
c= 3e8 // speed of light in m/s
// sample problem 15a page No. 306
printf("\n\n\n # Problem 15a # \n")
printf("\n Standard formula used E = m*c^2")
del_m = b_e * (1.6e-19) / c^2 * 1000
printf ("\n Loss in mass during formation of 1 atom
    of hydrogen is %e g.", del_m)
```

**Scilab code Exa 8.15.2** Calculation of binding energy of deuteron

```
clc
//Given that
M_p = 1.6725e-24 // mass of proton in g
M_n = 1.6748e-24 // mass of neutron in g
M_d = 3.3433e-24 // mass of deuteron in g
c= 3e8 // speed of light in m/s
// sample problem 15b page No. 306
printf("\n\n\n # Problem 15b # \n")

printf("\n Standard formula used E = m*c^2")
del_m = M_p + M_n - M_d // calculation of Loss in
    mass during formation of 1 atom of hydrogen

b_e = (del_m / 1000) * c^2 / (1.6e-19 * 1e6) //
    calculation of Binding energy of deuteron

printf ("\n Binding energy of deuteron is %f MeV.",
    b_e)
```

# Chapter 9

# Stars and their Classification

**Scilab code Exa 9.1** Calculation of change in brightness of a nova in 2 days

```
clc
//Given that
m_i = 15 // initial magnitude of supernova
m_f = 2 // final magnitude of supernova
// sample problem 1 page No. 332
printf("\n # Problem 1 # \n")

printf("Standard formula used \n\t M = m - 2.5log(L/L_0) ")
del_m = m_i - m_f // calculation of change in magnitude
brightness_ratio = 100^(del_m/5)  // calculation of increment in brightness ratio.
printf ("\n In two days novas brightness is increased by %d times nearly", ceil(brightness_ratio / 10000)*10000 )
```

**Scilab code Exa 9.2.1** Calculation of change in magnitude if brightness get doubled

```
clc
//Given that
b_ratio = 2 // ratio of light output in a period
// sample problem 2a page No. 333
printf("\n # Problem 2a # \n")

printf("Standard formula used \n\t M = m − 2.5 log(L/
    L_0) ")
del_m = 2.5 * log10(b_ratio) // calulation of change
     in magnitude
printf ("\n Change in magnitude is %f times", del_m
    )
```

**Scilab code Exa 9.2.2** Comparison of absolute brightness of Capella and sun

```
clc
// given that
m_capella = 0.05 // magnitude of brightness of
    capella at 14 parsecs
m_sun = 4.8 // absolute magnitude of brightness of
    sun
d = 14 // distance of capella in parsecs
D = 10 // distance of capella considerd for
    observation
```

```
// sample problem 2b page No. 333
printf("\n # Problem 2a # \n")

printf("Standard formula used \n\t M = m - 2.5log(L/
    L_0) ")
M_capella = m_capella - 5*log10(d/D) // calculation
    of absolute magnitude of brightness at distance
    of 10 parsecs
del_m = m_sun - M_capella // difference between
    absolute magnitude of sun and capella
ratio = 10^(del_m/2.5)
printf ("\n Capella is  %f times brighter than sun."
    , ratio )
```