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

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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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) * 1.6e-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 - 2.5log(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 )
```