

Scilab Textbook Companion for
Introduction To Special Relativity And Space
Science
by S. P. Singh¹

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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

```
1  clc //Given that
2  Beta=0.10//fringe width in cm
3  D=200// separation between source and screen in cm
4  lambda=0.00055// wavelength of incident light in cm
5  //Sample Problem 1 Page No. 46
6  printf ("\n # Problem 1 # \n")
7  d= (D*lambda)/ (10*Beta)
8  printf (" \n Standard formula used \n  beta= lambda*
          D/d \n")
9
10 printf ("\n Separation between sources is %f cm. \n"
         ,d)
```

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

```
1 clc
2 //Given that
3 D=80// separation between source and screen in cm
4 d=0.18// separation between sources in cm
5 n=4// order of fringe
6 x_n=1.08// distance from central bright fringe in cm
7 //Sample Problem 2 Page No. 47
8 printf("\n # Problem 2 # \n")
9 printf("\n Standard formula used \n      x_n= n*lambda
      *D/d \n")
10
11 lambda=d*x_n/(D*n)*1e7
12 printf("\n Wavelength of light used is %d Angstrom."
      , lambda)
```

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

```
1 clc
2 //Given that
3 beta=0.0320//fringe width in cm
4 D=100// separation between source and screen in cm
5 d=0.184// separation between sources in cm
6 //Sample Problem 3 Page No. 47
7 printf ("\n # Problem 3 # \n")
8 printf("\n Standard formula used      beta=lambda*D/d
      \n")
9
10 lambda=d*beta/D*1e8
11 printf("\n Wavelength of light used is %d Angstrom."
      , lambda)
```

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

```
1 clc
2 //Given that
3 beta=0.02//fringe width in cm
4 D=100// separation between source and screen in cm
5 u=30// separation between slit and convex lens in cm
6 I=0.7// separation between two images of slits on
   screen in cm
7 //Sample Problem4 Page No. 47
8 printf("\n # Problem 4 # \n")
9 printf(" \n Standard formula used \n beta=lambda*D/d
   \n")
10
11 v=100-u
12 O=I*u/v
13 d=0
14 lambda=d*beta/D*1e8
15 printf("\n Wavelength of light used is %d Angstrom."
   , lambda)
```

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

```
1 clc
2 //Given that
3 x_n=1.88// fringe separation of nth fringe from
   central fringe in cm
4 N=20// order of fringe
```

```

5 beta=0.02//fringe width in cm
6 D=120// separation between source and eyepiece in cm
7 d=0.076// separation between sources in cm
8 //Sample Problem 5 Page No. 47
9 printf ("\n # Problem 5 # \n")
10 printf ("\n Standard formula used \n    beta= lambda
    *D/d \n")
11 beta=x_n/N // calculation of angle formed
12 lambda=d*beta/D*1e8 // calculation of Wavelength of
    light
13 printf ("\n Wavelength of light used is %d Angstrom.
    ", lambda)

```

Scilab code Exa 1.6 Determination of fringe width in biprism experiment

```

1 clc
2 //Given that
3 mu = 1.5 // refractive index of plane glass prism
4 theta = %pi / 180 // angle of prism
5 y1 = 10 // separation between slit and biprism in cm
6 y2 = 100 //separation sbetween biprism and screen in
    cm
7 lambda = 0.00005893// wavelength of incident light
    in cm
8 //Sample Problem 6 Page No. 48
9 printf("\n # Problem 6 # \n")
10 printf("\n Standard formula used \n Beta = (D *
    lambda) / d")
11 d = 2 * ( mu -1) * theta * y1
12 D = y1 + y2
13 Beta = (D * lambda) / d
14 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

```
1 clc
2 //Given that
3 mu=1.52// refractive index of plane glass prism
4 theta=%pi/180// angle of prism
5 y1=25// separation between slit and biprism in cm
6 y2=175//separation between biprism and screen in cm
7 lambda=0.000055// wavelength of incident light in cm
8 beta=0.02//fringe width in cm
9 //Sample Problem 7 Page No. 49
10 printf("\\n # Problem 7 # \\n")
11 printf(" \\n Standard formula used \\n    beta= lambda*
    D/d. \\n")
12 D=y1+y2
13 d= (D*lambda)/beta
14 theta=d/(2*(mu-1)*y1)
15 vertex_angle=180-(2*theta*180/%pi)
16 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

```
1 clc
2 //Given that
3 mu=1.60// refractive index of plane glass prism
4 lambda=0.0000589// wavelength of incident light in
    cm
```



```

5 N=15// order of fringe
6 //Sample Problem 8 Page No. 49
7 printf("\n # Problem 8 # \n")
8 printf(" \n Standard formula used \n    del_x = D/2d
    *(mu-1)*t \n")
9 t=N*lambda/(mu-1)
10 printf("\n Thickness of sheet is %e cm.", t)

```

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

```

1 clc
2 //Given that
3 t=0.00035// thickness of glass sheet in cm
4 lambda=0.000055// wavelength of incident light in cm
5 N=4// order of fringe
6 //Sample Problem 9 Page No. 50
7 printf("\n # Problem 9 # \n")
8 printf(" \n Standard formula used \n    (mu    1 )*t
    = n* lambda \n")
9 mu=N*lambda/t+1
10 printf("\n Refractive index of sheet is %f .", mu)

```

Scilab code Exa 1.10 Determination of lowest order which will be absent from light

```

1 clc
2 //Given that
3 t = 5e-5 // thickness of soap film in cm
4 theta = 35 // angle of view in degree
5 mu = 1.33 // refractive index of soap film

```

```

6 // sample problem 10 page No. 50
7 printf("\n # Problem 10 # \n")
8 a = 0
9 printf("Standard formula used \n\t 2*mu*t*cos(r) = n
      *lambda ")
10 r = asin (sin(theta * %pi /180) / mu)
11 for n = 1:3
12     lambda = 2 * mu * t * cos(r) / n
13     if lambda > t then
14         a = a + 1
15     end
16 end
17 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

```

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

```

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

```
1 clc
2 //Given that
3 D15=0.59// diameter of 15th newtons ring in cm
4 D5=0.336// diameter of 5th newtons ring in cm
5 R=100// radius of Plano convex lens in cm
6 //Sample Problem 12 Page No. 51
7 printf("\n # Problem 12 # \n")
8 p=15-5
9 printf(" \n Standard formula used \n D_a^2      D_b^2
      = 4*p*R*lambda \n")
10
11 lambda=(D15^2 - D5^2)/(4*p*R)*1e8
12 printf("\n Wavelength of light used is %d Angstrom."
      , lambda)
```

Scilab code Exa 1.13 Calculation of refractive index of air

```
1 clc
2 //Given
3 t=40// length of tube in cm
4 lambda=5e-5// wavelength of incident light in cm
5 n=150// order of fringe
6 //Sample Problem 13 Page No. 52
7 printf("\n # Problem 13 # \n")
8 printf(" \n Standard formula used \n      (mu      1 )*t
      = n* lambda \n")
```

```

9 t=n*lambda/t+1
10 printf("\n Refractive index of oil film is %f .", t
)

```

Scilab code Exa 1.14 Calculation of thickness of air film

```

1 clc
2 //Given
3 no_fringe = 250 // Number of fringes observed
  through telescope
4 lambda1 = 4e-5 // wavelength of incident light in cm
5 lambda2 = 6.5e-5 // wavelength of incident light in
  cm
6
7 //Sample Problem 14 Page No. 52
8 printf("\n # Problem 14 # \n")
9 printf(" \n Standard formula used \n 2*t = p*lambda
  ")
10 p = no_fringe * lambda1 / (lambda2- lambda1)
11 t = p * lambda2 / 2
12 printf("\n Thickness of air film is %f cm. ", t)

```

Scilab code Exa 1.15 Calculation of thickness of oil film

```

1 clc
2 //Given
3 mu_oil=1.3 // refractive index of oil
4 mu_glass=1.5 // refractive index of glass
5 lambda1=5e-7 // wavelength of incident light in cm

```

```

6 lambda2=7e-7// wavelength of incident light in cm
7
8 //Sample Problem 15 Page No. 52
9 printf("\n # Problem 15 # \n")
10 printf(" \n Standard formula used \n      2*mu*t*cos r
      = (p +0.5)*lambda \n")
11 p= ((lambda2+lambda1)/ (lambda2-lambda1))/2
12 t= ((p+0.5)*lambda1)/ (2*mu_oil)*1e10
13 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

```

1 clc
2 //Given
3 lambda=5.6e-5// wavelength of incident light in cm
4 f=4//focal length in meter
5 mu=1.5// refractive index of glass\
6 n=4// order of fringe
7 //Sample Problem 16 Page No. 53
8 printf ("\n # Problem 16 # \n")
9 printf(" \n Standard formula used \n      D_n= sqrt
      (2*(2*n-1)*lambda*R \n")
10 R= (mu-1)*2*f
11 D_4=sqrt (2*(2*n-1)*lambda*R*100)
12 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 use

```

1  clc
2  //Given
3  D_5=0.336 // diameter of fifth ring in cm
4  D_15=0.59 // diameter of fifteenth ring in cm
5  lambda=5.893e-5 // wavelength of incident light in cm
6  p=10
7  //Sample Problem 17 Page No. 53
8  printf("\n # Problem 17 # \n")
9  printf(" \n Standard formula used \n   D_{n+p} ^2
          D_n^2 = 4*p*R*lambda \n")
10 r= ((D_15^2-D_5^2)/ (4*p*lambda))
11 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 u

```

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

```

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

```
1 clc
2 //Given
3 lambda=5.9e-5// wavelength of incident light in cm
4 n=10// order of ring
5 //Sample Problem 18b Page No. 54
6 printf(" \n # Problem 18b # \n")
7 printf(" \n Standard formula used \n      2t = n*lambda
      \n")
8 t=n*lambda/200
9 printf(" Thickness of air film is %e m.\n ",t)
```

Scilab code Exa 1.19 Determination of radius of curvature of Plano convex lens use

```
1 clc
2 //Given
3 mu=4/3
4 D_10=0.6// diameter of tenth ring in cm
5 lambda=6.0e-5// wavelength of incident light in cm
6 n=10// order of ring
7
8 //Sample Problem 19 Page No. 54
9 printf(" \n # Problem 19 # \n")
10 printf(" \n Standard formula used \n      D_n^2 = 4*n*
      lambda*R/mu \n")
11 R= (mu*D_10^2/ (4*n*lambda))
12
13 printf(" Radius of curvature of lens is %d cm.\n ",
      ceil(R))
```

Scilab code Exa 1.20 Determination of wavelength of light using grating

```
1 clc
2 //Given
3 grating_element=6000// lines per centimeter
4 theta=30// angle of second order spectral line in
   degree
5 n=2// order
6
7 //Sample Problem 20 Page No. 54
8 printf("\n # Problem 20 # \n")
9 printf(" \n Standard formula used \n    n*lambda= (a+
   b)*sin(theta) \n")
10
11 lambda=sin(theta*%pi/180)/(grating_element*n)
12 printf(" Wavelength is %e cm.\n",lambda)
```

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

```
1 clc
2 //GivenS
3 lambda=6.2e-5// wavelength of monochromatic light in
   cm
4 grating_element= 1/5000// lines per centimeter
5 theta=90// angle of second order spectral line in
   degree
6
7 //Sample Problem 21 Page No. 55
```



```

8 printf("\n # Problem 21 # \n")
9 printf(" \n Standard formula used \n    n*lambda= (a+
    b)*sin(theta) \n")
10 n=grating_element/lambda
11 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 spec

```

1 clc
2 //Given
3 lambda=5.5e-5// wavelength of monochromatic light in
    cm
4 grating_element=1/4000// lines per centimeter
5 n=3// order of spectrum
6
7 //Sample Problem 22 Page No. 55
8 printf("\n # Problem 22 # \n")
9 printf(" \n Standard formula used \n    n*lambda= (a+
    b)*sin(theta)\n")
10 sin_theta=n*lambda/grating_element
11 cos_theta=sqrt(1-sin_theta^2)
12 disp_pow=n/ (grating_element*cos_theta)
13 printf (" Dispersive power    is %d. \n ",disp_pow)

```

Scilab code Exa 1.23.1 Determination of clearly observation between two wavelength

```

1 clc
2 // Given That

```

```

3 lambda1=5.89e-5// wavelength in cm
4 lambda2=5.896e-5//wavelength in cm
5 n=1// for second order spectrum
6 t = 2 // width of detraction grating
7 grating_element = 425 // no. of lines per cm
8 //Sample Problem 23a Page No. 56
9
10 printf("\n # Problem 23a # \n")
11 printf(" \n Standard formula used \n   lambda /
        d_lambda = n*N \n")
12 total_line = t * grating_element
13 printf("\n Total number of lines on diffraction
        grating is %d \n So",total_line)
14 N=lambda1/ (lambda2-lambda1)/n
15 if (N > total_line) then
16 printf ("\n Lines will not be resolved in %d order
        .",n)
17 printf("\nas %d lines are required for diffraction
        ", N)
18 else printf("\nas %d lines are required for
        diffraction are. ", N)
19     printf (" Lines will be resolved in %d order",
        n)
20 end

```

Scilab code Exa 1.23.2 Determination of clearly observation between two wavelength

```

1 clc
2 // Given That
3 lambda1=5.89e-5// wavelength in cm
4 lambda2=5.896e-5//wavelength in cm
5 n=2// for second order spectrum
6 t = 2 // width of diffraction grating

```

```

7 grating_element = 425 // no. of lines per cm
8 //Sample Problem 23b Page No. 56
9
10 printf("\n # Problem 23b # \n")
11 printf(" \n Standard formula used \n   lambda /
        d_lambda = n*N \n")
12 total_line = t * grating_element
13 printf("\n Total number of lines on diffraction
        grating %d \n \n So",total_line)
14 N=lambda1/ (lambda2-lambda1)/n
15 if (N > total_line) then
16 printf ("\n   ,Lines will not be resolved in %d order
        .",n)
17 printf("\nas %d lines are required for diffraction
        are   ", N)
18 else printf ("   Lines will be resolved in %d order",
        n)
19     printf("\nas %d lines are required for
        diffraction are . ", N)
20 end

```

Scilab code Exa 1.24 Calculation of maximum number of lines two just resolve two w

```

1 clc
2 // Given That
3 lambda1=5.89e-5// wavelength in cm
4 lambda2=5.896e-5//wavelength in cm
5 t=2.5// width of grating in cm
6 n=2// for second order spectrum
7 //Sample Problem 24 Page No. 56
8
9 printf("\n # Problem 24 # \n")
10 printf(" \n Standard formula used \n   lambda /

```

```

        d_lambda = n*N \n")
11 N=lambda1/ (lambda2-lambda1)/n
12 grating_element=N/t
13 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 w

```

1 clc
2 // Given That
3 a=12e-5// slit width in cm
4 lambda1=5.89e-5// wavelength in cm
5 lambda2=5.896e-5//wavelength in cm
6 n=2// for second order spectrum
7 //Sample Problem 25 Page No. 56
8 printf("\n # Problem 25 # \n")
9 printf(" \n Standard formula used \n   lambda /
        d_lambda = n*N \n\n")
10 d_lambda = lambda2-lambda1
11 grating_element= lambda1/ (d_lambda*n)
12
13 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 Fraun

```

1 clc
2 // Given That
3 a = 12e-5 // slit width in cm

```

```

4 lambda = 6e-5 // wavelength in cm
5 //Sample Problem 26 Page No. 57
6 printf("\n # Problem 26 # \n")
7 printf(" \n Standard formula used \n      a*sin(theta )
      = lambda \n")
8 theta = asin((lambda / a))
9 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

```

1 clc
2 // Given That
3 lambda1 = 5.9e-5 // wavelength in cm
4 lambda2 = 5.896e-5 //wavelength in cm
5 lambda = 5.89e-5 // wavelength in cm
6 grating_element = 4000 // lines per cm
7 t = 4 // width of grating in cm
8 n = 1 // for first order spectrum
9 //Sample Problem 27 Page No. 58
10 printf("\n # Problem 27 # \n")
11 printf(" \n Standard formula used \n      lambda /
      d_lambda = n* N )\n")
12
13 N = t * grating_element
14 Resolv_pow = lambda /(lambda2 - lambda)
15 N = Resolv_pow / n
16
17 if (grating_element > N ) then
18     printf("Grating will well resolve two spectral
      lines. \n")
19     end

```

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

```
1 clc
2 // Given That
3 aperture=6.4e-3// linear aperture in cm
4 lambda=6.24e-5// wavelength in cm
5 f=50// separation between lens and screen in cm
6 n=1// for first order spectrum
7 //Sample Problem 28 Page No. 58
8 printf("\n # Problem 28 # \n")
9 printf(" \n Standard formula used \n  a*sin(theta )
    = lambda \n")
10 sin_theta=n*lambda/aperture
11 d=f*sin_theta
12 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

```
1 clc
2 // Given That
3 theta = 60 // angle between plane of vibration of
    incident beam with optic axis
4
5 //Sample Problem 29 Page No. 859
6 printf("\n # Problem 29 # \n ")
7 printf("Standard formula used is \n  $I = A^2 * \cos^2(\theta)$  \n")
```

```

8 ratio = (tan(theta*pi /180))^2 // ratio of
    extraordinary and ordinary intensities
9 printf("Ratio of extraordinary and ordinary
    intensities is %f .", ratio)

```

Scilab code Exa 1.30 Calculation of thickness of half wave plate

```

1 clc
2 // Given That
3 mu_e = 1.553 // refractive index of quartz plate for
    extra ordinary light
4 mu_o = 1.544 // refractive index of quartz plate for
    ordinary light
5 lambda = 5.89e-5 // wavelength of light in Angstrom.
6 //Sample Problem 30 Page No. 859
7 printf("\n # Problem 30 # \n ")
8 printf("Standard formula used is \n lambda= 2t(mu_e-
    mu_o) \n")
9 t = lambda / (2 * (mu_e - mu_o))
10 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

```

1 clc
2 // Given That
3 lambda=5e-5// wavelength in cm
4 mu_e=1.5533// refractive index for extraordinary
    light

```

```

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

```

Scilab code Exa 1.32 Calculation of difference between refractive indices

```

1 clc
2 // Given That
3 lambda=5.89e-5// wavelength in cm
4 rotation=(%pi/18)// rotation of plane of
      polarization in degree per cm
5
6 //Sample Problem 32 Page No. 60
7 printf ("\n # Problem 32 # \n ")
8 printf (" \n Standard formula used \n   delta=pi*d*
      del_mu/lambda \n")
9 del_mu=rotation*lambda/ (%pi)
10 printf ("Difference in refractive indices of
      substance is %e .\n",del_mu)

```

Scilab code Exa 1.33 Determination of specific rotation of sugar solution

```

1 clc

```



```

2 // Given That
3 rotation=13.2// in degree
4 conc=0.1// gram per cubic cm
5 l=2// length of tube in dm
6 //Sample Problem 33 Page No. 60
7 printf("\n # Problem 33 # \n ")
8 printf(" \n Standard formula used \n      delta=pi*d*
      del_mu/lambda \n")
9 s= (rotation*(%pi/180))/ (l*conc)
10 specific_rotation=s*180/%pi
11 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

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

Scilab code Exa 2.3 Determination of amplitude of electric field

```
1 clc
2 // Given That
3 I = 2.4 // intensity of radiation in Watt per meter
      square
4 epsilon_0 = 8.85e-12
5 c = 3e8
6 //Sample Problem 3 Page No. 80
7 printf("\\n # Problem 3 # \\n ")
8 E = sqrt ((2* I)/ (c * epsilon_0)) // calculation of
      amplitude of electric field is
9 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

```
1 clc
2 // Given That
3 l = 75 // length of laser beam in cm
4 power = 6e-3 // power of beam in mW
5 c = 3e8
6 //Sample Problem 4 Page No. 80
7 printf("\\n # Problem 4 # \\n ")
8 t = 1 / ( c * 100) //calculation of time taken to
      cover distance
9 U = power/1000 * t//calculation of Energy stored in
      given length
```

```
10 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

```
1 clc  
2 // Given That  
3 E_0 = 300 // maximum electric field in  
    electromagnetic wave in w/m  
4 v = 2e8 // speed of moving electron in m/s along y -  
    axis  
5 c = 3e8 // speed of light in m/s  
6 q = 1.6e-19 // charge on electron in coulomb  
7 //Sample Problem 6 Page No. 81  
8 printf ("\n # Problem 6 # \n ")  
9 B_0 = E_0 / c // calculation of magnitude of  
    maximum magnetic field  
10 F_e = q*E_0 // calculation of electromagnetic force  
    on electron in N  
11 F_b = q*v*B_0 // calculation of magnetic force on  
    electron in N  
12 printf ("The maximum electric force on electron is  
    %e N along y -axis \n", F_e)  
13 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

```
1 clc
```

```

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

```

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

```

Scilab code Exa 2.9 Calculation of electric flux through plane circle due to unifor

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

```
1 clc
2 // Given That
3 A = 200 // magnitude of electric field in V/m^2
4 epsilon_0 = 8.85e-12 // permittivity of free space
5 a = 20 // radius of sphere in cm
6 //Sample Problem 10Page No. 84
7 printf("\n # Problem 10 # \n ")
```

```

8 q = 4*%pi * epsilon_0*A*(a*1e-2)^3 //calculation of
  Charge contained in sphere
9 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

```

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

```

1 clc
2 // Given That
3 phi = 0.02 // rate of change of magnetic field in T/
  s

```

```

4 r = 2 // radius of frame in cm
5 R = 2 // resistance of frame in m ohm
6 //Sample Problem 12 Page No. 85
7 printf("\n # Problem 12 # \n ")
8 a = %pi * (r*1e-2)^2
9 e = a * phi // magnitude of emf induced in coil
10 i = (e) / (R*1e-3)
11 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

```

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

```

1 clc
2 // Given That
3 solar_const = 2 // energy received by earth from sun
    in Cal/min cm2

```



```

4 mu_not = 1.2566e-6 // universal constant
5 epsilon_not = 8.85e-12 // universal constant
6 //Sample Problem 14 Page No. 86
7 printf("\n # Problem 14 # \n ")
8 ratio = sqrt(mu_not / epsilon_not) // constant
9 E = sqrt (ratio *4.2 * solar_const / 6e-3)
10 E_not = E * sqrt(2) //calculation of Amplitude of
    electric vectors
11 H_not = E_not / ratio//calculation of Amplitude of
    magnetic vectors
12 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 r

```

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

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

Scilab code Exa 3.2 Calculation of energy of ejected photoelectrons

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

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

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

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

Scilab code Exa 3.4 Calculation of velocity of a moving electrons

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

Scilab code Exa 3.5 Determination of threshold wavelength for photoemission

```
1 clc
2 //Given that
3 phi = 6 // work function in eV
4 h = 6.624e-34 // plank's constant
5 c = 3e8 // speed of light
6 e = 1.6e-19 // charge on electron
```

```

7 m_e = 9.1e-31
8 //Sample Problem 5 Page No. 137
9 printf("\n\n\n # Problem 5 # \n")
10 printf("\n Standard formula Used \n phi = h * nu")
11 lambda = h * c / (phi * e) * 1e10//calculation of
    Longest wavelength to eject electron
12 printf("\n Longest wavelength to eject electron is
    %d Angstroms. ", lambda)

```

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

```

1 clc
2 //Given that
3 theta = %pi/2 // scattering angle of photon
4 h = 6.624e-34 // plank's constant
5 c = 3e8 // speed of light
6 e = 1.6e-19 // charge on electron in coulomb
7 m_e = 9.1e-31 // mass of electron in kg
8 //Sample Problem 6 Page No. 137
9 printf("\n\n\n # Problem 6 # \n")
10 printf("\n Standard formula Used \n delta_lambda = h
    * (1 - cos (theta )) / ( m_e * c)")
11 delta_lambda = h * (1 - cos (theta )) / ( m_e * c) //
    calculation of Change in wavelength of electron
12 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

```

1  clc
2  //Given that
3  angle = %pi/2 // scattering angle of photon
4  h = 6.624e-34 // plank's constant
5  v = 2e6 // speed of particle
6  e = 1.6e-19 // charge on electron
7  m = 1e-3 // mass of particle in kg
8  //Sample Problem 7 Page No. 137
9  printf("\n\n\n # Problem 7 # \n")
10 printf("\n Standard formula Used \n lambda = h / (m
    * v)")
11 lambda = h / (m * v) //calculation of de Broglie
    wavelength of particle
12 printf("\n de Broglie wavelength of particle is %e
    m.", lambda)
13 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

```

1  clc
2  //Given that
3  lambda = 4.3e-7 // wavelength of light in meter
4  phi_Ni = 5 // work function of nickel in eV
5  h = 6.624e-34 // plank's constant
6  c = 3e8 // speed of light
7  m_e = 9.1e-31 // mass of electron in kg
8  //Sample Problem 8a Page No. 138
9  printf("\n\n\n # Problem 8a # \n")
10 lambda_threshold = h * c / (phi_Ni*1e-19) //

```

```

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

```

Scilab code Exa 3.8.2 Determination of possibility of photo emission and velocity of

```

1 clc
2 //Given that
3 lambda = 4.3e-7 // wavelength of light in meter
4 phi_K = 2.3 // work function of nickel in eV
5 h = 6.624e-34 // plank's constant
6 c = 3e8 // speed of light
7 m_e = 9.1e-31 // mass of electron in kg
8 //Sample Problem 8b Page No. 138
9 printf("\n\n\n # Problem 8b # \n")
10 lambda_threshold = h * c / (phi_K *1.6e-19) //
    calculation of longest wavelength required
11 if (lambda_threshold < lambda) then
12     printf("As the threshold wavelength is less than
        wavelength of incident radiation Soelectron
        will not be ejected \n")
13 else

```

```

14     v = sqrt((2* h * c *( lambda_threshold - lambda)
              ) / (m_e * lambda_threshold * lambda )) //
              calculation of ejected velocity Electron
15     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)
16 end

```

Scilab code Exa 3.9 Determination of wavelength for which the second order Bragg r

```

1  clc
2  //Given that
3  d = 3.04 // inter layer separation in Angstrom
4  theta = 14.7 // in degree
5  n = 2 // order of brags reflection
6  //Sample Problem Page No. 139
7  printf("\n\n\n # Problem 9 # \n")
8  printf("\n Standard formula Used \n 2 * d * sin(
          theta) = n * lambda")
9  lambda = 2 * d * sin( theta * (%pi /180))/ n //
          calculation of wavelength making second order
          Brags reflection
10 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


```

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

```

Scilab code Exa 3.10.2 Calculation of angle for secondary maxima

```

1  clc
2  //Given that
3  n = 2 // order
4  lambda = 5.2e-11 // wavelength in Angstrom
5  d = 2.98e-10 // interatomic separation in Angstrom
6  //Sample Problem 10b page No. 139
7  printf("\n\n\n # Problem 10b # \n")
8  printf("\n Standard formula Used \n 2 * d * sin(
      theta) = n * lambda ")
9  theta_rad = asin ( (n * lambda) / ( 2 * d)) //
    calculation of angle for secondary maxima in
    radian
10 theta_deg = theta_rad * 180 / %pi //calculation of
    angle for secondary maxima in degree
11 printf ("\n Angle for secondary maxima is %d. ",
    theta_deg )

```

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

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

Scilab code Exa 3.12 Calculation of uncertainty inn momentum of electron if it is

```
1 clc
2 //Given that
```

```

3 r = 1e-14 // radius of nucleus of atom in meter
4 h = 6.626e-34 // Plank's constant
5 //Sample Problem 12 page No. 140
6 printf("\n\n\n # Problem 12 # \n")
7 printf("\n Standard formula Used \n delta_p *
    delta_x >= h /(2*pi)")
8 del_x = 2 * r //calculation of Uncertainty in
    position
9 del_p = h / (2 * %pi * del_x) //calculation of
    Uncertainty in momentum
10 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

```

1 clc
2 //Given that
3 v = 300 // speed of electron in m/s
4 accuracy = 1e-4 // accuracy in speed
5 h = 6.6e-34 // Plank's constant
6 m_e = 9.1e-31 // mass of electron in Kg
7 //Sample Problem 13 page No. 140
8 printf("\n\n\n # Problem 13 # \n")
9 printf("\n Standard formula Used \n delta_p *
    delta_x >= h /(2*pi)")
10 del_p = accuracy * m_e * v //calculation of
    Uncertainty in momentum
11 del_x = h / (4 * %pi * del_p) //calculation of
    Uncertainty in position
12 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

```
1 clc
2 //Given that
3 lambda1 = 6560 // wavelength in Angstrom
4 n1 = 1 // transition state no
5 n2 = 2 // transition state no
6 n3 = 3 // transition state no.
7 //Sample Problem 14 page No. 141
8 printf("\n\n\n # Problem 14 # \n")
9 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)"
   )
10 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
11 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

```
1 clc
2 //Given that
3 m = 2e-3 // mass of linear harmonic oscillator in kg
4 k = 100 // spring constant in N/m
5 h = 6.6e-34 // Plank's constant
6 //Sample Problem 15 page No. 142
```

```

7 printf("\n\n\n # Problem 15 # \n")
8 printf("\n Standard formula Used \n f = sqrt(k / m
) \n U = 1/2* h * nu ")
9 nu = sqrt(k / m ) / (2 * %pi) //calculation of
frequency of linear harmonic oscillator
10 U = 1/2* h * nu //calculation of Zero point energy
of a linear harmonic oscillator
11 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 s

```

1 clc
2 //Given that
3 R = 1.097 // Rydbergs constant
4 n1 = 1 // transition state no
5 n2 = 2 // transition state no
6 //Sample Problem 16a page No. 142
7 printf("\n\n\n # Problem 16a # \n")
8 printf ("\n Standard formula Used \n For Lyman
series 1/lambda = R*((1/2) ^2 - (1/n) ^2)")
9 nu1 = R * (n2^2 - n1^2) / (n1^2 * n2^2) //
calculation of frequency of first line of Lyman
series
10 lambda1 = 1/ nu1//calculation of Wavelength of first
line of Lyman series
11 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

```
1 clc
2 //Given that
3 R = 1.097 // Rydbergs constant
4 n1 = 1 // transition state no
5 n2 = 3 // transition state no
6 //Sample Problem 16b page No. 142
7 printf("\n\n\n # Problem 16b # \n")
8 printf("\n Standard formula Used \n For Lyman series
   1/lambda = R*((1/2)^2 -(1/n)^2)")
9 nu1 = R * (n2^2 - n1^2) / (n1^2 * n2^2) //
   calculation of frequency of first line of Lyman
   series
10 lambda1 = 1/ nu1 //calculation of Wavelength of
   first line of Lyman series
11 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

```
1 clc
2 //Given that
3 lambda1 = 4700 // wavelength in Angstrom
4 lambda2 = 1.4e-5//wavelength in cm
5 temp1 = 6174 // temperature of a black of in kelvin
6 //Sample Problem 17 page No. 143
7 printf("\n\n\n # Problem 17 # \n")
8 printf("\n Standard formula Used \n lambda * T =
   constant")
9 temp2 = lambda1 * temp1 / (lambda2 * 1e8) //
   calculation of temperature
10 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

```
1 clc
2 //Given that
3 lambda = 1 // wavelength in Angstrom
4 theta = 90 // angle of scattered photon in degree
5 m_e = 9.11e-31 // mass of electron in Kg
6 c = 3e8 // speed of light in m/s
7 h = 6.63e-34 // plank 's constant
8 //Sample Problem 19a page No. 144
9 printf("\n\n\n # Problem 19a # \n")
10 printf("\n Standard formula Used \n delta_lambda = h
      * (1 - cos (theta )) / ( m_e * c)")
11 lambda_shift = h *(1 - cos(theta * %pi / 180))/ (
      m_e * c) //calculation of Change in frequency
12 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 Compt

```
1 clc
2 //Given that
3 lambda1 = 1 // wavelength in Angstrom
4 lambda2 = 1.0243 // wavelength in Angstrom
5 c = 3e8 // speed of light in m/s
6 h = 6.63e-34 // plank 's constant
7 //Sample Problem 19b page No. 144
```

```

8 printf("\n\n\n # Problem 19b # \n")
9 printf("\n Standard formula Used \n E= h *(nu1
    nu2)")
10 K = h * c * (( lambda2 - lambda1 )/ (lambda1 *
    lambda2 )) *(10e9 / 1.6e-19) //calculation of
    Kinetic energy imparted to recoiling
11 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

```

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

```
1 clc
2 //Given that
3 lambda1 = 1.321 // wavelength of L- alpha line for
   platinum
4 lambda2 = 4.174 // wavelength of l - alpha line of
   unknown substance
5 z1= 78// atomic number of platinum
6 c = 3e8 // speed of light in m/s
7 b = 7.4 // constant for L - alpha line
8 //Sample Problem 21 page No. 146
9 printf("\\n\\n\\n # Problem 21 # \\n")
10 printf("\\n Standard formula Used \\n sqrt(nu1)= a*(Z-
   b)")
11 z2 = b + (z1 - b) * sqrt(lambda1 / lambda2) //
   calculation of the unknown substance has atomic
   number
12 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

```
1 clc
2 //Given that
3 h = 6.6e-34 // plank's constant
4 m_e = 9.1e-31 // mass of electron in kg
5 L = 1e-10 // length of box of particle in m
```

```

6 //Sample Problem 22 page No. 146
7 printf("\n # Problem 22 # \n")
8 printf("\n Standard formula Used \n E= h^2 * (n_x^2+
    n_y^2+n_z^2) / (8*m*L^2)")
9 sum = 0
10 n_y = 1
11     for n_x = 1:3
12
13         for n_z = 1:2
14             sum = n_x+n_y+n_z
15             if sum<6 then
16                 E = h^2 * (n_x^2+n_y^2+n_z^2) /
                    (1.6e-19*8*m_e*L^2) //
                    calculation of energy
17             printf("\n \n E%d%d%d is  %f eV. ",
                    n_x,n_y,n_z,E)
18             end
19
20
21
22         end
23     end

```

Chapter 4

Frame of Reference

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

```
1  clc
2  //Given that
3  F = [2.5,4.5,-5] // F is a force vector act through
    origin
4  // sample Problem 1 Page No. 176
5  printf("\n\n\n # Problem 1 # \n")
6  F_magnitude = sqrt ( 2.5^2 + 4.5^2 + (-5)^2)
7  theta_x = (180 / %pi ) * acos ( 2.5 / F_magnitude)
8  theta_y = (180 / %pi ) * acos ( 4.5 / F_magnitude)
9  theta_z = (180 / %pi ) * acos ( -5 / F_magnitude)
10 printf ( " \n Magnitude of force F is %f N",
    F_magnitude)
11 printf(" \n Angle made with X - axis is %f degree",
    theta_x)
12 printf(" \n Angle made with Y - axis is %f degree" ,
    theta_y)
13 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

```
1 clc
2 //Given that
3 r = [2,2,2*sqrt(2)]
4
5 // sample Problem 2a Page No. 176
6 printf("\n\n\n # Problem 2a # \n")
7 r_magnitude = sqrt ( 2^2 + 2^2 + (2*sqrt(2))^2)
8 cos_x = ( 2 / r_magnitude)
9 cos_y = ( 2 / r_magnitude)
10 cos_z = ( 2.8284 / r_magnitude)
11 printf(" \n Directional cosine in X – axis is %f ",
        cos_x)
12 printf(" \n Directional cosine in Y – axis is %f " ,
        cos_y)
13 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

```
1 clc
2 //Given that
3 r_xz = [2,2.8282]
4 // sample Problem 2b Page No. 176
5 printf("\n\n\n # Problem 2b # \n")
6 r_xz = sqrt (2^2 + (2.8282)^2)
7 r_yz = sqrt (2^2 + (2.8282)^2)
```

```

8 printf (" \n Projection of vector r in xz plane is
%f", r_xz)
9 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

```

1 clc
2 //Given that
3 d1 = [5,-5,-4] // initial coordinate point of vector
d
4 d2 = [6,2,-2] // final coordinate point of vector d
5 F1 = [10,-1,10] // first force acting on particle
6 F2 = [4,5,6] // second force acting on particle
7 F3 = [-2,1,-9] // third force acting on particle
8
9
10 // sample Problem 3 Page No. 177
11 printf("\n \n\n # Problem 3 # \n")
12 d = d2 - d1 // d is vector of displacement
13 F = F1 + F2 + F3 // F is resultant of all the force
14 printf("Standard formula used is  $W = F*d$  \n ")
15 W = F * d'
16 printf(" \n Total work done is %d units ", W)

```

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

```

1 clc
2 //Given that

```

```

3 v_w_x = 40 * cos(45 * %pi / 180) // x component of
  wind blow in miles/h
4 v_w_y = 40 * sin(45 * %pi /180) // y component of
  wind blow in miles/h
5 r_x = 200 // distance of destination point in x
  direction in miles
6 r_y = 0 // distance of destination point in y
  direction in miles
7 t = 40 // time taken by aeroplane to reach
  destination in minutes
8 // sample Problem 4 Page No. 177
9 printf("\n # Problem 4 # \n")
10 printf("Standard formula used is V = V1 + V2 +
  .....+ V_n \n ")
11 v_x = (r_x)/t *60 // x - component of velocity
  required to reach destination in time in miles/h
12 v_y = r_y /t *60 // x - component of velocity
  required to reach destination in time in miles/h
13 v_p_x = v_x - v_w_x // x component of aeroplane
  velocity in miles/h
14 v_p_y = v_y - v_w_y // y component of aeroplane
  velocity in miles/h
15 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

```

1 clc
2 //Given that
3 R_e = 6.4e6 // radius of earth in m
4 T = 8.64e4 // time period of one rotation of earth

```

```

5 theta_pole = 90 // angle between pole and rotational
  axis
6 theta_equator = 0 // angle between equator and
  rotational axis
7 g_pole = 9.8 // gravitational acceleration at pole
  in m/s^2
8 // sample Problem 5 Page No. 178
9 printf ("\n\n\n # Problem 5 # \n")
10 printf("Standard formula used is  $g_1 = g - R_e * f^2 * (\cos(\theta))^2$  \n ")
11 f = 2 * %pi / T // rotational frequency of earth
12 g_equator = g_pole - R_e * f^2
13 del_g = g_pole - g_equator
14 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

```

1 clc
2 //Given that
3 R_e = 6.4e6 // radius of earth in m
4 theta_pole = 90 // angle between pole and rotational
  axis
5 theta_equator = 0 // angle between equator and
  rotational axis
6 g_pole = 10 // gravitational acceleration at pole in
  m/s^2
7 g_equator = 0 // gravitational acceleration at
  equator in m/s^2
8 // sample Problem 6 Page No. 178
9 printf ("\n\n\n # Problem 6 # \n")
10 printf("Standard formula used is  $g_1 = g - R_e * f^2 * (\cos(\theta))^2$  \n ")

```

```

11 f = sqrt (g_pole / R_e)
12 T = 2 * %pi / f / 3.6e3
13 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

```

1 clc
2 //Given that
3 g_pole = 9.8 // gravitational acceleration at pole
4 m = 1 // mass of substance in kg
5 R_e = 6.4e6 // radius of earth in m
6 // sample Problem 7 Page No. 179
7 printf("\n # Problem 7 # \n")
8 printf("Standard formula used is \n coriolis force =
    -2*m*f x v\n \n")
9 g_equator = 0.75 *g_pole // gravitational
    acceleration at equator in m/s^2
10 f = sqrt ((g_pole - g_equator)/ R_e)
11 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 act

```

1 clc
2 //Given that
3 m = 1 // mass of particle in kg
4 theta = 30 // latitude position in degree

```



```

5 v = 0.5 // velocity of particle in km/s in north
   direction
6
7
8 // sample Problem 8 Page No. 180
9 printf("\n # Problem 8 # \n")
10 printf("Standard formula used is coriolis Force = 2*
   mass*angular velocity X velocity ")
11 f_x = -2*m*2*%pi * v*1000*(-1)*sin(theta*%pi/180)
   /86400 // coriolis force in east direction
12 f_z = -2*m*2*%pi * v*1000*cos(theta*%pi/180)/86400
   // coriolis force in verticle direction
13 F = sqrt(f_x^2+f_z^2)
14 alpha = -atan(f_z/f_x) *180 /%pi
15 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

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

Scilab code Exa 6.2 Determination of relative velocity between two photons approach

```
1 clc
2 //Given that
3 c = 3e8 // speed of light in m/s
4 u_x_ = -3e8 // velocity of first photon in ground
   frame in m/s
5 v = -3e8 // velocity of second photon in ground
   frame in m/s
6 // sample problem 2 page No. 222
7 printf("\n \n\n # Problem 2 # \n")
8 printf("\n Standard formula used is  u_x = (u_x_ + v
   ) / (1 + v * u_x_ / c^2) ")
9 u_x = (u_x_ + v) / (1 + v * u_x_ / c^2) //
   calculation of Velocity of photon with respect to
   another
10 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 approach

```
1 clc
2 //Given that
3 c = 3e8 // speed of light in m/s
4 u_x_ = -0.9 * c // velocity of first spaceship in
   ground frame in m/s
```

```

5 v = -0.9 * c // velocity of second spaceship in
   ground frame in m/s
6 // sample problem 3 page No. 222
7 printf("\n \n\n # Problem 3 # \n")
8 printf("\n Standard formula used is  $u_x = (u_{x_0} + v$ 
   ) / (1 + v *  $u_{x_0} / c^2$ ) ")
9  $u_x = (u_{x_0} + v) / (1 + v * u_{x_0} / c^2)$  //
   calculation of Velocity of photon
10 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

```

1 clc
2 //Given that
3 E = 7.5e11 // Energy in kWh
4 c = 3e8 // speed of light in m/s
5 // sample problem 4 page No. 223
6 printf("\n \n\n # Problem 4 # \n")
7 printf("\n Standard formula used \n  $E = m * c^2$ ")
8 m = (E * 3.6e6) / c^2 // calculation of Amount of mass
   consumed
9
10 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

```

1 clc
2 //Given that

```

```

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

```

Scilab code Exa 6.6 Calculation of relativistic mass

```

1 clc
2 //Given that
3 m_0 = 1e-24 // mass of moving particle in kg
4 v = 1.8e8 // speed of particle in m/s
5 c = 3e8 // speed of light in m/s
6 // sample problem 6 page No. 223
7 printf("\n \n\n # Problem 6 # \n")
8 printf("\n Standard formula used \n m = m_0/ sqrt (
   1- (v/c)^2)")
9 m = m_0 / sqrt(1 - (v / c)^2) // calculation of
   Relativistic mass of particle
10 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

```

1 clc
2 //Given that

```

```

3 c = 3e8 // speed of light in m/s
4 v = 0.5 * c // speed of particle in m/s
5 // sample problem 7 page No. 223
6 printf("\n \n\n # Problem 7 # \n")
7 printf("\n Standard formula used \n m = m_o/sqrt (
      1- (v/c)^2)")
8 ratio = sqrt(1- (v /c)^2) // calculation of Ratio of
      rest mass and relativistic mass of particle
9 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

```

1 clc
2 //Given that
3 ratio = 0.5 // Ratio of lengths of spaceship
4 c = 3e8 // speed of light in m/s
5 // sample problem 8a page No. 224
6 printf("\n \n\n # Problem 8a # \n")
7 printf("\n Standard formula used \n l = l_o* sqrt (
      1- (v/c)^2)")
8 v = c * sqrt(1 - ratio^2) // calculation of Speed of
      spaceship
9 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

```

1 clc
2 //Given that

```

```

3 c = 3e8 // speed of light in m/s
4 v = 2.598e8 // speed of spaceship
5 t_0 = 1 // time in second
6 // sample problem 8b page No. 224
7 printf("\n \n\n # Problem 8b # \n")
8 printf("\n Standard formula used \n t= t_0/ sqrt (
    1- (v/c)^2)")
9 t = t_0 / sqrt(1 - (v ^2 / c ^2) ) // calculation of
    Time corresponding to 1 sec
10 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

```

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

```

1  clc
2  //Given that
3  c = 3e8 // speed of light in m/s
4  m_0 = 1 // atomic mass in amu
5  m = 3 * m_0 // relativistic mass
6  // sample problem 10 page No. 225
7  printf("\\n \\n\\n # Problem 10 # \\n")
8  printf("\\n Standard formula used  $l = l_0 * \sqrt{1 - (v/c)^2}$ ")
9  v = c * sqrt(1- (m_0 / m)^2) // calculation of
    Velocity of particle
10 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 tw

```

1  clc
2  //Given that
3  mass_ratio = 0.5 // Ratio of rest mass and
    relativistic mass
4  c = 3e8 // speed of light in m/s
5  // sample problem 11 page No. 225
6  printf("\\n # Problem 11 # \\n")
7  printf("\\n Standard formula used  $m = m_0 / \sqrt{1 - (v/c)^2}$ ")
8  v = c * sqrt(1- mass_ratio^2) // calculation of
    Velocity of particle
9  printf ("\\n Velocity of particle is %f c.", v / c )

```

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


```

1  clc
2  //Given that
3  c = 3e8 // speed of light in m/s
4  u_x_ = -2e8 // velocity of first photon in ground
      frame in m/s
5  v = -2e8 // velocity of second photon in ground
      frame in m/s
6  m_0 = 3e-25
7  // sample problem 12 page No. 226
8  printf("\n \n\n # Problem 12a # \n")
9  printf("\n Standard formula used \n u_x = (u_x_ + v)
      / (1 + v * u_x_ / c^2)")
10 u_x = (u_x_ + v) / (1 + v * u_x_ / c^2) //
      calculation of Velocity of photon with respect to
      another
11 m = m_0 / sqrt(1 - (u_x / c)^2) // calculation of
      Relativistic mass of particle with respect to
      another
12 printf ("\n Velocity of photon with respect to
      another is %e m/s.",u_x)
13 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

```

1  clc
2  //Given that
3  c = 3e8 // speed of light in m/s
4  ratio = 1.95e+03 // Ratio of relativistic mass and
      rest mass
5  // sample problem 14b page No. 227
6  printf("\n \n\n # Problem 14b # \n")
7  printf("\n Standard formula used \n m = m_0/ sqrt (

```

```

1- (v/c)^2)”)
8 ratio_1 = 1 / (2* ratio^2) // calculation of ratio
of velocity to velocity of light for
9 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

```

1 clc
2 //Given that
3 c = 3e8 // speed of light in m/s
4 u = 0.9*c // velocity of first particle with respect
to other in m/s
5 density1 = 19.3e-3 // density of gold in rest frame
6 // sample problem 13 page No. 226
7 printf (“\n \n\n # Problem 13 # \n”)
8 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)
”)
9 mass_ratio = sqrt (1 - (u/c)^2) // calculation of
ratio of relativistic mass
10 volume_ratio = 1 / sqrt (1 - (u/ c)^2) //
calculation of ratio of relativistic volume
11 density2 = density1 * (volume_ratio /mass_ratio ) //
calculation of ratio of relativistic density
12 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

```

1  clc
2  //Given that
3  E = 1e9 // energy of electron in eV
4  c = 3e8 // speed of light in m/s
5  m_0 = 9.1e-31 // mass of electron in kg
6  // sample problem 14 page No. 227
7  printf("\n \n\n # Problem 14a # \n")
8  printf("\n Standard formula used \n E = m*c^2")
9  m = E / c^2 * 1.6e-19 // calculation of
    relativistic mass of particle
10 ratio = m / m_0 // calculation of Ratio of
    relativistic mass and rest mass of particle
11 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

```

1  clc
2  //Given that
3  c = 3e8 // speed of light in m/s
4  ratio = 1.95e+03 // Ratio of relativistic mass and
    rest mass
5  // sample problem 14b page No. 227
6  printf("\n \n\n # Problem 14b # \n")
7  printf("\n Standard formula used \n m = m_0/ sqrt (
    1- (v/c)^2)")
8  ratio_1 = 1 / (2* ratio^2) // calculation of ratio
    of velocity to velocity of light for
9  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

```
1 clc
2 //Given that
3 m = 9e-31 // mass in kg
4 E = 1e9 // Energy of accelerated electron in eV
5 c = 3e8 // speed of light in m/s
6 // sample problem 14c page No. 227
7 printf("\n \n\n # Problem 14c # \n")
8 printf("\n Standard formula used \n E = m*c^2")
9 E_0 = m * c^2 // calculation of rest mass energy
10 ratio = E / E_0 *1.6e-19 // calculation of Ratio of
    energy to rest mass energy
11 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

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

```

9 l = l_ / sqrt (1 - (v / c)^2) // calculation of
  Proper length of rod
10 printf ("\n Proper length of rod is %f m.",l )

```

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

```

1 clc
2 //Given that
3 c = 3e8 // speed of light in m/s
4 v = 0.9 * c // velocity of rod wrt laboratory
5 proper_time = 2.5e-8 // proper mean life time of
  mesons
6 // sample problem 16 page No. 228
7 printf ("\n \n\n # Problem 16 # \n")
8 printf ("\n Standard formula used \n t = t_o /sqrt (
  1- (v/c)^2)")
9 t = proper_time / sqrt (1 - (v / c)^2) //
  calculation of New mean life time
10 printf ("\n New mean life time is %e s.",t )

```

Scilab code Exa 6.17 Determination of velocity of electron having relativistic ene

```

1 clc
2 //Given that
3 E = 1 // energy of electron in MeV
4 c = 3e8 // speed of light in m/s
5 m_0 = 9e-31 // rest mass of electron
6 // sample problem 17 page No. 229
7 printf ("\n \n\n # Problem 17 # \n")

```

```

8 printf("\n Standard formula used \n m = m_o* sqrt (
    1- (v/c)^2) \n and \n E=m*c^2")
9 m = E * 1.6e-13 / c^2 // calculation of mass of
    electron
10 v = c * sqrt(1 - (m_0 / m)^2) // calculation of
    Velocity of electron
11 printf ("\n Velocity of electron is %e m/s.",v )

```

Scilab code Exa 6.19 Calculation of distance travelled by meson

```

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

```

Scilab code Exa 6.20 Determination of speed if mass is increased by 1 per cent

```

1  clc
2  //Given that
3  c = 3e8 // speed of light in m/s
4  m = 1 // let
5  m_change = 1 // change in mass in percentage by
    increasing velocity
6  // sample problem 20 page No. 230
7  printf("\\n \\n\\n # Problem 20 # \\n")
8  printf("\\n Standard formula used \\n m = m_o* sqrt (
    1- (v/c)^2) ")
9  v = c * sqrt (1 - (m / (m + m_change/100))^2) //
    calculation of Velocity required to increase mass
    by one percent
10 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

```

1  clc
2  //Given that
3  c = 3e8 // speed of light in m/s
4  m_ratio = 2000 // ratio of rest mass and
    relativistic mass
5  // sample problem 21 page No. 231
6  printf("\\n \\n\\n # Problem 21 # \\n")
7  printf("\\n Standard formula used \\n m = m_o* sqrt (
    1- (v/c)^2) ")
8  v = c * sqrt (1 - (1/m_ratio)^2) // calculation of
    Velocity required to increase mass by 2000 times
9
10 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 pro

```
1 clc
2 //Given that
3 h = 6.63e-34 // plank's constant
4 c = 3e8 // speed of light in m/s
5 lambda = 5e-4 // wavelength of photon in angstrom
6 e_rest_mass = 0.511 // rest mass of electron in Mev/
   c^2
7 p_rest_mass = 0.511 // rest mass of electron in Mev/
   c^2
8 // sample problem 22 page No. 230
9 printf("\n \n\n # Problem 22 # \n")
10 printf("\n Standard formula used \n E_total = E_rest
   + E_kinetic")
11 k = (((h * c / (lambda * 1.6e-23 )) - (e_rest_mass
   + p_rest_mass))) /2 // calculation of Energy of
   each particle
12 printf( "\n Energy of each particle is %f MeV.", k
   )
```

Scilab code Exa 6.23 Determination of threshold wavelength for proton antiproton p

```
1 clc
2 //Given that
3 h = 6.63e-34 // plank's constant
4 c = 3e8 // speed of light in m/s
5 p_rest_mass = 938 // rest mass of proton in Mev/
```



```

6 ap_rest_mass = 938 // rest mass of antiproton in Mev
7 // sample problem 23 page No. 232
8 printf("\n \n\n # Problem 23 # \n")
9 printf("\n Standard formula used \n E = h* c /
    lambda")
10 lambda = h * c / ((p_rest_mass + ap_rest_mass) * 1.6
    e-19) // calculation of Threshold wavelength for
    proton - antiproton production
11 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 1Be

```

1 clc
2 //Given that
3 c = 3e8 // speed of light in m/s
4 p_rest_mass = 0.938 // rest mass energy of proton in
    BeV
5 KE = 1 // kinetic energy of proton in BeV
6 // sample problem 24 page No. 232
7 printf("\n \n\n # Problem 24 # \n")
8 printf("\n Standard formula used  $E^2 = p^2*c^2 + m_0^2*c^4$ ")
9 E = KE + p_rest_mass // calculation of energy of
    particle
10 p = (sqrt (E^2 *1e6 - (p_rest_mass * 1e3)^2)) *(1.6e
    -19)*(1e9) / c // calculation of Momentum of
    photon
11 printf( "\n Momentum of photon is %e kg m/s.", p)

```

Scilab code Exa 6.26 Determination of speed of meson

```
1 clc
2 //Given that
3 c = 3e8 // speed of light in m/s
4 t = 8e-6 // mean life of meson
5 l = 10 // distance of meson from earth surface
6 // sample problem 26 page No. 228
7 printf("\\n \\n\\n # Problem 26 # \\n")
8 printf("\\n Standard formula used \\n l = l_0* sqrt (
    1- (v/c)^2)")
9 v = 1*1e3/ sqrt( t^2 +(1 * 1e3 /c)^2) // calculation
    of relative speed of meson with respect to
10 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

```
1 clc
2 //Given that
3 c = 3e8 // speed of light in m/s
4 v = 0.8 *c // velocity of rod in m/s
5 m_0 = 1.673e-27 // rest mass of proton in kg
6 // sample problem 27 page No. 228
7 printf("\\n \\n\\n # Problem 27 # \\n")
8 printf("\\n Standard formula used \\n E_total = KE +
    E_mass")
```

```
9 K_E = m_0 * c^2 *(1/sqrt(1-(v/c)^2) - 1) / 1.6e-13
    // calculation of Kinetic energy of proton
10 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

```
1  clc
2  //Given that
3  t1 = 1 // time period of satellite s1 in hours
4  t2 = 8 // time period of satellite s2 in hour
5  r1 = 1.2e4 // radius of orbit of satellite s1 in km
6
7  // sample problem 4a page No. 300
8  printf("\n\n\n # Problem 4a # \n")
9
10 printf("Standard formula  $r_2/r_1 = (t_2/t_1)^{(2/3)}$ ")
11 r2 = r1 * (t2/t1)^(2/3) // calculation of radius of
    orbit of satellite s2 in km
12 v1 = 2 * %pi * r1 / t1 // calculation of speed of
    satellite s1 in km/h
13 v2 = 2 * %pi * r2 / t2 // calculation of speed of
    satellite s2 in km/h
14 del_v = v2 - v1 // calculation of relative speed of
    satellites in km/h
15
```

```
16 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

```
1 clc
2 //Given that
3 t1 = 1 // time period of satellite s1 in hour
4 t2 = 8 // time period of satellite s2 in hour
5 r1 = 1.2e4 // radius of orbit of satellite s1 in km
6
7 // sample problem 4b page No. 300
8 printf ("\n\n\n # Problem 4b # \n")
9
10 printf ("Standard formula  $r_2/r_1 = (t_2/t_1)^{(2/3)}$ ")
11 r2 = r1 * (t2/t1)^(2/3) // calculation of radius of
    orbit of satellite s2 in km
12 v1 = 2 * %pi * r1 / t1 // calculation of speed of
    satellite s1 in km/h
13 v2 = 2 * %pi * r2 / t2 // calculation of speed of
    satellite s2 in km/h
14 del_v = v2 - v1 // calculation of relative speed of
    satellites in km/h
15 del_r = r2 - r1 // calculation of closest distance
    between satellite s1 and s2
16 v_angular = del_v / del_r // calculation of angular
    speed in rad/h
17 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 sa

```
1 clc
2 //Given that
3 h = 2620 // distance of satellite from surface of
   Earth in km
4 R_e = 6400 // radius of Earth in km
5 M_e = 6e24 // mass of Earth in kg
6 G = 6.67e-11 // universal gravitational constant
7
8 // sample problem 5 page No. 300
9 printf("\\n\\n\\n # Problem 5 # \\n")
10
11 printf("Standard formula used \\n\\t v_o = sqrt(G*M_e/
   r) \\n ")
12 printf("\\n \\t T = 2 * pi * r / v_o \\n ")
13 r = R_e + h
14 v_o = sqrt(G * M_e / (r * 1e3))
15 T = 2 * %pi * r*1000 / (v_o*3600)
16 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 sa

```
1 clc
2 //Given that
3 h = 3e5 // distance of satellite from surface of
   Earth in m
```

```

4 R_e = 6.38e6 // radius of Earth in km
5 M_e = 6e24 // mass of Earth in kg
6 g = 9.8 // gravitational acceleration in m/s2
7
8 // sample problem 6 page No. 301
9 printf("\n\n\n # Problem 6 # \n")
10
11 printf("Standard formula used v_o = sqrt(G*M_e/r) \n
      ")
12 printf("Standard formula used T = 2 * pi * r / v_o \
      \n ")
13 r = R_e + h // calculation of effective distance
      between Earth and satellite
14
15 G = g * R_e^2 / M_e // calculation of gravitational
      constant
16 v_o = sqrt(G * M_e / r) / 1000 // calculation of
      orbital velocity of satellite
17 T = 2 * %pi * r / (v_o * 1000) / 3.6e3 //
      calculation of period of revolution of satellite
18
19 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

```

1 clc
2 //Given that
3 t = 27.3 // period of lunar orbit around Earth in
      days
4 r = 3.9e5 // distance of satellite from Earth in km
5 G = 6.67e-11 // universal gravitational constant
6 // sample problem 7 page No. 301

```

```

7 printf("\n # Problem 7 # \n")
8 printf("Standard formula used \n  $T = 2 * \pi * \sqrt{\frac{r^3}{G * M_e}}$  \n ")
9 T = t * 24 * 60 * 60 // calculation of time in
    seconds
10 M_e = 4 * %pi^2 * (r * 1000)^3 / (G * T^2) //
    calculation of mass of Earth
11 printf ("\n Estimated mass of Earth is %e kg.", M_e)

```

Scilab code Exa 8.8 Estimation of mass of sun

```

1 clc
2 //Given that
3 t = 1 // period of Earth's revolution around Sun in
    years
4 r = 1.5e8 // distance between Sun and Earth in km
5 G = 6.67e-11 // Universal gravitational constant
6 // sample problem 8 page No. 302
7 printf("\n\n\n # Problem 8 # \n")
8 printf("Standard formula used  $T = 2 * \pi * \sqrt{\frac{r^3}{G * M_e}}$  \n ")
9 T = t * 24 * 60 * 60 * 365 // calculation of time
    period in seconds
10 M_s = 4 * %pi^2 * (r * 1000)^3 / (G * T^2) //
    calculation of mass of Sun
11 printf ("\n Estimated mass of Sun is %e kg.", M_s)

```

Scilab code Exa 8.9 Determination of height achieved by Rocket


```

1  clc
2  //Given that
3  R_e = 6.4e6 // radius of Earth in km
4  M_e = 6e24 // mass of Earth in kg
5  G = 6.67e-11 // universal gravitational constant
6  u = 6e3 // initial speed of rocket in m/s
7
8  // sample problem 9 page No. 302
9  printf("\n\n\n # Problem 9 # \n")
10
11 printf("Standard formula used  $U_f - U_i = 1/2 * m * ($ 
     $u^2 - v^2)$ \n ")
12 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
13
14 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 pa

```

1  clc
2  //Given that
3  R_e = 6.4e6 // radius of Earth in km
4  M_e = 6e24 // mass of Earth in kg
5  G = 6.67e-11 // universal gravitational constant
6  // sample problem 10 page No. 303
7  printf("\n\n\n # Problem 10 # \n")
8
9  printf("Standard formula used  $U_f - U_i = 1/2 * m * ($ 
     $u^2 - v^2)$ \n ")
10 h = 10 * R_e
11 v = sqrt (2 *h * G * M_e / (R_e * h)) //

```

```

        calculation of velocity required by mass to reach
        given height
12 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

```

1  clc
2  //Given that
3  r1 = 1e12 // distance of first planet from Sun in m
4  r2 = 1e13 //distance of first planet from Sun in m
5  // sample problem 11 page No. 304
6  printf("\n\n\n # Problem 11 # \n")
7
8  printf("Standard formula used  $T^2 = k * r^3$ ")
9  printf ("\n Standers formula used  $v = 2 * pi * r / T$ 
        ")
10 r_ratio = r1 / r2 // r_ratio is ratio of distances
        from Sun
11 T_ratio = r_ratio^(3/2) //calculation of Ratio of
        time period
12 v_ratio = r_ratio / T_ratio // calculation of ratio
        of speed
13
14 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

```

1  clc

```

```

2 //Given that
3 r1 = 1.5e8 // distance of Earth from Sun in km
4 t1 = 1 // let
5 // sample problem 12 page No. 305
6 printf ("\n\n\n # Problem 12 # \n")
7
8 printf ("\n Standard formula used  $T^2 = k * r^3$ ")
9 t2 = 29.5 * t1 // calculation of time period of
   Saturn
10 r2 = r1 * (t2 / t1) ^ (2/3) //calculation of
   distance of stern from Sun
11
12 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

```

1 clc
2 //Given that
3 r_peri = 360 // distance of perigee of satellite
   from Earth surface in km
4 r_apo = 2500 // distance of apogee of satellite from
   Earth surface in km
5 R_e = 6400 // radius of Earth in km
6 v_p = 30000 // speed of satellite at apogee position
   in km/h
7 // sample problem 13 page No. 305
8 printf ("\n\n\n # Problem 13 # \n")
9
10 printf ("\n Standard formula used  $v * r = k$  ")
11 r_p = r_peri + R_e // calculation of distance of
   perigee
12 r_a = r_apo + R_e // calculation of distance of

```

```

    apogee
13
14 v_a = v_p * r_p / r_a // calculation of speed at
    apogee
15 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

```

1 clc
2 //Given that
3 h = 600 // distance of satellite from surface of
    Earth in km
4 R_e = 6400 // radius of Earth in km
5 m_s = 100 // mass of satellite in kg
6 g = 10 // gravitational acceleration in m/s2
7 v_y = 2500 // upward velocity of launched satellite
8 // sample problem 14 page No. 306
9 printf ("\n\n\n # Problem 14 # \n")
10
11 printf ("\n Standard formula used  $1/2 * (m_s * v^2 /$ 
     $r) = g * R_E^2 * m / R_e^2$  ")
12 r = R_e + h // calculation of effective height of
    satellite
13
14 v = sqrt (g * (R_e * 1e3)^2 / (r * 1e3)) //
    calculation of orbital velocity of satellite
15
16 P_x = m_s * v // calculation of momentum in x
    direction
17 P_y = m_s * v_y // calculation of momentum in y
    direction
18 U = sqrt (P_x^2 + P_y^2 ) // calculation of magnitude

```

```

        of impulse required
19
20 theta = (180 / %pi) * atan (P_y / P_x ) //
        calculation of direction of impulse required
21 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 h

```

1 clc
2
3 //Given that
4 b_e = 13.6 // Binding energy of electron to proton
        in eV
5 c= 3e8 // speed of light in m/s
6 // sample problem 15a page No. 306
7 printf ("\n\n\n # Problem 15a # \n")
8 printf ("\n Standard formula used E = m*c^2")
9 del_m = b_e * (1.6e-19) / c^2 * 1000
10 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

```

1 clc
2 //Given that
3 M_p = 1.6725e-24 // mass of proton in g
4 M_n = 1.6748e-24 // mass of neutron in g

```

```
5 M_d = 3.3433e-24 // mass of deuteron in g
6 c= 3e8 // speed of light in m/s
7 // sample problem 15b page No. 306
8 printf("\n\n\n # Problem 15b # \n")
9
10 printf("\n Standard formula used E = m*c^2")
11 del_m = M_p + M_n - M_d // calculation of Loss in
    mass during formation of 1 atom of hydrogen
12
13 b_e = (del_m / 1000) * c^2 / (1.6e-19 * 1e6) //
    calculation of Binding energy of deuteron
14
15 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

```
1  clc
2  //Given that
3  m_i = 15 // initial magnitude of supernova
4  m_f = 2 // final magnitude of supernova
5  // sample problem 1 page No. 332
6  printf("\n # Problem 1 # \n")
7
8  printf("Standard formula used \n\t M = m - 2.5 log(L/
   L_0) ")
9  del_m = m_i - m_f // calculation of change in
   magnitude
10 brightness_ratio = 100^(del_m/5) // calculation of
   increment in brightness ratio.
11 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

```
1 clc
2 //Given that
3 b_ratio = 2 // ratio of light output in a period
4 // sample problem 2a page No. 333
5 printf("\\n # Problem 2a # \\n")
6
7 printf("Standard formula used \\n\\t  $M = m - 2.5 \log(L/L_0)$  ")
8 del_m = 2.5 * log10(b_ratio) // calculation of change
    in magnitude
9 printf ("\\n Change in magnitude is %f times", del_m
    )
```

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

```
1 clc
2 // given that
3 m_capella = 0.05 // magnitude of brightness of
    capella at 14 parsecs
4 m_sun = 4.8 // absolute magnitude of brightness of
    sun
5 d = 14 // distance of capella in parsecs
6 D = 10 // distance of capella considered for
    observation
7 // sample problem 2b page No. 333
8 printf("\\n # Problem 2a # \\n")
```



```
9
10 printf("Standard formula used \n\t M = m - 2.5log(L/
      L_0) ")
11 M_capella = m_capella - 5*log10(d/D) // calculation
      of absolute magnitude of brightness at distance
      of 10 parsecs
12 del_m = m_sun - M_capella // difference between
      absolute magnitude of sun and capella
13 ratio = 10^(del_m/2.5)
14 printf ("\n Capella is %f times brighter than sun."
      , ratio )
```
