Scilab Textbook Companion for Theory Of Machines by B. K. Sarkar[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.

Contents

List of Scilab Codes

Chapter 1

Basic kinemtics

Scilab code Exa 1.1 Length of the stroke

```
//CHAPTER 1 ILLUSRTATION 1 PAGE NO 15
//TITLE:Basic kinematics
//Figure 1.14
clc
clear
pi=3.141
AO=200//                  distance between fixed centres in mm
OB1=100//                 length of driving crank in mm
AP=400//                  length of slotter bar in mm
//==========================================
OAB1=asind(OB1/AO)//              inclination of slotted bar with vertical in degrees
beeta=(90-OAB1)*2//               angle through which crank turns inreturn stroke in degrees
A=(360-beeta)/beeta//             ratio of time of cutting stroke to the time of return stroke
L=2*AP*sind(90-(beeta)/2)//       length of the stroke in mm
printf('Inclination of slotted bar with vertical= %
```

```
.3f degrees\n Length of the stroke= %.3f mm',OAB1
,L)
```

Scilab code Exa 1.2 Ratio of time taken on the cutting to the return stroke

```
//CHAPTER 1 ILLUSRTATION 2 PAGE NO 16
//TITLE:Basic kinematics
//Figure 1.15
clc
clear
OA=300//                  distance between the fixed
   centres in mm
OB=150//                    length of driving crank in
   mm
//==========================================
OAB=asind(OB/OA)//                  inclination of
   slotted bar with vertical in degrees
beeta=(90-OAB)*2//                   angle through which
    crank turns inreturn stroke in degrees
A=(360-beeta)/beeta//                ratio of time of
   cutting stroke to the time of return stroke
printf('Ratio of time taken on the cutting to the
   return stroke= %.0f',A)
```

Scilab code Exa 1.3 Ratio of time taken on the cutting to the return stroke

```
//CHAPTER 1 ILLUSRTATION 3 PAGE NO 16
//TITLE:Basic kinematics
//Figure 1.16
clc
clear
```

```
OB=54.6//                    distance between the fixed
   centres in mm
OA=85//                      length of driving crank in
   mm
OA2=OA
CA=160//                     length of slotted lever in
   mm
CD=144//                     length of connectin rod in
   mm
//===================================
beeta=2*(acosd(OB/OA2))//        angle through which
    crank turns inreturn stroke in degrees
A=(360-beeta)/beeta//              ratio of time of
   cutting stroke to the time of return stroke
printf('Ratio of time taken on the cutting to the
   return stroke= %.0f',A)
```

Scilab code Exa 1.4 Angular velocity of connecting rod

```
//CHAPTER 1 ILLUSRTATION 4 PAGE NO 17
//TITLE:Basic kinematics
//Figure 1.18,1.19
clc
clear
pi=3.141
Nao=180//     speed of the crank in rpm
wAO=2*pi*Nao/60//  angular speed of the crank in rad
   /s
AO=.5//           crank length in m
AE=.5
Vao=wAO*AO//       velocity of A in m/s
//===================================
Vb1=8.15//     velocity of piston B in m/s by
   measurment from figure 1.19
Vba=6.8//     velocity of B with respect to A in m/s
```

```
AB=2//         length of connecting rod in m
wBA=Vba/AB//       angular velocity of the connecting rod BA in rad/s
ae=AE*Vba/AB//      velocity of point e on the connecting rod
oe=8.5//           by measurement velocity of point E
Do=.05//           diameter of crank shaft in m
Da=.06//           diameter of crank pin in m
Db=.03//           diameter of cross head pin B m
V1=wAO*Do/2//              velocity of rubbing at the pin of the crankshaft in m/s
V2=wBA*Da/2//              velocity of rubbing at the pin of the crank in m/s
Vb=(wAO+wBA)*Db/2//        velocity of rubbing at the pin of cross head in m/s
ag=5.1//                  by measurement
AG=AB*ag/Vba//       position and linear velocity of point G on the connecting rod in m
//==================================================
printf('Velocity of piston B= %.3f m/s\n Angular velocity of connecting rod= %.3f rad/s\n velocity of point E=%.1f m/s\n velocity of rubbing at the pin of the crankshaft=%.3f m/s\n velocity of rubbing at the pin of the crank =%.3f m/s\n velocity of rubbing at the pin of cross head =%.3f m/s\n position and linear velocity of point G on the connecting rod=%.3f m',Vb1,wBA,oe,V1,V2,Vb,AG)
```

Scilab code Exa 1.5 Linear velocity of point P

```
//CHAPTER 1 ILLUSRTATION 5 PAGE NO 19
//TITLE:Basic kinematics
//Figure 1.20,1.21
```

```
clc
clear
pi=3.141
N=120//      speed of crank in rpm
OA=10//      length of crank in cm
BP=48//      from figure 1.20 in cm
BA=40//      from figure 1.20 in cm
//==================
w=2*pi*N/60//        angular velocity of the crank OA
     in rad/s
Vao=w*OA//          velocity of ao in cm/s
ba=4.5//            by measurement from 1.21 in cm
Bp=BP*ba/BA
op=6.8//            by measurement in cm from figure
    1.21
s=20//              scale of velocity diagram 1cm=20
    cm/s
Vp=op*s//           linear velocity of P in m/s
ob=5.1//            by measurement in cm from figure
     1.21
Vb=ob*s//           linear velocity of slider B
printf('Linear velocity of slider B= %.2f cm/s\n
    Linear velocity of point P= %.2f cm/s',Vb,Vp)
```

Scilab code Exa 1.6 velocity of point F

```

//CHAPTER 1 ILLUSRTATION 6 PAGE NO 20
//TITLE:Basic kinematics
//Figure 1.22,1.23
clc
clear
pi=3.141
AB=6.25//      length of link AB in cm
BC=17.5//      length of link BC in cm
```

```
CD=11.25//     length of link CD in cm
DA=20//        length of link DA in cm
CE=10
N=100//        speed of crank in rpm
//==========================================
wAB=2*pi*N/60//       angular velocity of AB in rad/s
Vb=wAB*AB//           linear velocity of B with respect to A
s=15//       scale for velocity diagram 1 cm= 15 cm/s
dc=3//       by measurement in cm
Vcd=dc*s
wCD=Vcd/CD//        angular velocity of link CD in rad/s
bc=2.5//     by measurement in cm
Vbc=bc*s
wBC=Vbc/BC//      angular velocity of link BC in rad/s
ce=bc*CE/BC
ae=3.66//        by measurement in cm
Ve=ae*s//           velocity of point E 10 from c on the link BC
af=2.94//        by measurement in cm
Vf=af*s//        velocity of point F
printf('The angular velocity of link CD= %.3f rad/s\n The angular velocity of link BC= %.3f rad/s\n velocity of point E 10 from c on the link BC= %.3f cm/s\n velocity of point F= %.3f cm/s',wCD,wBC,Ve,Vf)
```

Scilab code Exa 1.7 angular velocity of link BD

```
//CHAPTER 1 ILLUSRTATION 7 PAGE NO 21
//TITLE:Basic kinematics
//Figure 1.24,1.25
clc
```

```
clear
pi=3.141
Noa=600//      speed of the crank in rpm
OA=2.8//       length of link OA in cm
AB=4.4//       length of link AB in cm
BC=4.9//       length of link BC in cm
BD=4.6//       length of link BD in cm
//==========================
wOA=2*pi*Noa/60//        angular velocity of crank in rad/s
Vao=wOA*OA//             The linear velocity of point A with respect to oin m/s
s=50//                   scale of velocity diagram in cm
od=2.95//                by measurement in cm from figure
Vd=od*s/100//            linear velocity slider in m/s
bd=3.2//                 by measurement in cm from figure
Vbd=bd*s
wBD=Vbd/BD//     angular velocity of link BD
printf('linear velocity slider D= %.3f m/s\n angular velocity of link BD= %.1f rad/s',Vd,wBD)
```

Scilab code Exa 1.8 Angular velocity of link CD

```
//CHAPTER 1 ILLUSRTATION 8 PAGE NO 22
//TITLE:Basic kinematics
//Figure 1.26,1.27
clc
clear
pi=3.141
Noa=60//         speed of crank in rpm
OA=30//      length of link OA in cm
```

```
AB=100//        length of link AB in cm
CD=80//         length of link CD in cm
//AC=CB
//==================
wOA=2*pi*Noa/60//      angular velocity of crank in rad/s
Vao=wOA*OA/100//       linear velocity of point A with respect to O
s=50//          scale for velocity diagram 1 cm= 50 cm/s
ob=3.4//        by measurement in cm from figure 1.27
od=.9//         by measurement in cm from figure 1.27
Vcd=160//       by measurement in cm/s from figure 1.27
wCD=Vcd/CD//    angular velocity of link in rad/s
printf('Angular velocity of link CD= %d rad/s',wCD)
```

Scilab code Exa 1.9 velocity of sliding of the block

```
//CHAPTER 1 ILLUSRTATION 9 PAGE NO 23
//TITLE:Basic kinematics
//Figure 1.28,1.29
clc
clear
pi=3.141
Nao=120//             speed of the crank in rpm
OQ=10//               length of link OQ in cm
OA=20//               length of link OA in cm
QC=15//               length of link QC in cm
CD=50//               length oflink CD in cm
//===============
wOA=2*pi*Nao/60//       angular speed of crank in rad/s
```

```
Vad=wOA*OA/100//          velocity of pin A in m/s
BQ=41//                 from figure 1.29
BC=26//                 from firure 1.29
bq=4.7//                 from figure 1.29
bc=bq*BC/BQ//            from figure 1.29 in cm
s=50//                   scale for velocity diagram in cm/s
od=1.525//               velocity vector od in cm from figure 1.29
Vd=od*s//                velocity of ram D in cm/s
dc=1.925//               velocity vector dc in cm from figure 1.29
Vdc=dc*s//               velocity of link CD in cm/s
wCD=Vdc/CD//             angular velocity of link CD in cm/s
ba=1.8//                 velocity vector of sliding of the block in cm
Vab=ba*s//               velocity of sliding of the block in cm/s
printf('Velocity of RAM D= %.3f cm/s\n angular velocity of link CD= %.3f rad/s\n velocity of sliding of the block= %.3f cm/s',Vd,wCD,Vab)
```

Scilab code Exa 1.10 angular acceleration of connecting rod BA

```
//CHAPTER 1 ILLUSRTATION 10 PAGE NO 24
//TITLE:Basic kinematics
//Figure 1.30(a),1.30(b),1.30(c)
clc
clear
pi=3.141
Nao=300//          speed of crank in rpm
AO=.15//           length of crank in m
BA=.6//            length of connecting rod in m
//=========================
```

```
wAO=2*pi*Nao/60//          angular velocity of link in
    rad/s
Vao=wAO*AO//               linear velocity of A with
   respect to 'o'
ab=3.4//          length of vector ab by measurement
   in m/s
Vba=ab
ob=4//          length of vector ob by measurement in
   m/s
oc=4.1//          length of vector oc by measurement
   in m/s
fRao=Vao^2/AO//     radial component of acceleration
   of A with respect to O
fRba=Vba^2/BA//      radial component of acceleration
    of B with respect to A
wBA=Vba/BA//         angular velocity of connecting
   rod BA
fTba=103//          by measurement in m/s^2
alphaBA=fTba/BA//     angular acceleration of
   connecting rod BA
printf('linear velocity of A with respect to O= %.3f
    m/s\n radial component of acceleration of A with
    respect to O= %.3f m/s^2\n radial component of
   acceleration of B with respect to A= %.3f m/s^2\n
    angular velocity of connecting rod B= %.3f rad/s
   \n angular acceleration of connecting rod BA= %.3
   f rad/s^2',Vao,fRao,fRba,wBA,alphaBA)
```

Scilab code Exa 1.11 angular acceleration of AB

```
//CHAPTER 1 ILLUSRTATION 11 PAGE NO 26
//TITLE:Basic kinematics
//Figure 1.31(a),1.31(b),1.31(c)
clc
clear
```

```
pi=3.141
wAP=10//            angular velocity of crank in rad/s
P1A=30//            length of link P1A in cm
P2B=36//            length of link P2B in cm
AB=36//             length of link AB in cm
P1P2=60//           length of link P1P2 in cm
AP1P2=60//          crank inclination in degrees
alphaP1A=30//       angulare acceleration of crank P1A in rad/s^2
//==========================================
Vap1=wAP*P1A/100//    linear velocity of A with respect to P1 in m/s
Vbp2=2.2//              velocity of B with respect to P2 in m/s(measured from figure )
Vba=2.06//              velocity of B with respect to A in m/s(measured from figure )
wBP2=Vbp2/(P2B*100)//   angular velocity of P2B in rad/s
wAB=Vba/(AB*100)//      angular velocity of AB in rad/s
fAB1=alphaP1A*P1A/100//  tangential component of the acceleration of A with respect to P1 in m/s^2
frAB1=Vap1^2/(P1A/100)//  radial component of the acceleration of A with respect to P1 in m/s^2
frBA=Vba^2/(AB/100)//     radial component of the acceleration of B with respect to B in m/s^2
frBP2=Vbp2^2/(P2B/100)//    radial component of the acceleration of B with respect to P2 in m/s^2
ftBA=13.62//                tangential component of B with respect to A in m/s^2(measured from figure)
ftBP2=26.62//               tangential component of B with respect to P2 in m/s^2(measured from figure)
alphaBP2=ftBP2/(P2B/100)//   angular acceleration of P2B in m/s^2
alphaBA=ftBA/(AB/100)//      angular acceleration of AB in m/s^2
//============================
```

```
printf('Angular acceleration of P2B=%.3f rad/s^2\n angular acceleration of AB =%.3f rad/s^2',
   alphaBP2,alphaBA)
```

Scilab code Exa 1.12 Accelaration of the slider

```
//CHAPTER 1 ILLUSRTATION 12 PAGE NO 28
//TITLE:Basic kinematics
//Figure 1.32(a),1.32(b),1.32(c)
clc
clear
PI=3.141
AB=12//    length of link AB in cm
BC=48//    length of link BC in cm
CD=18//    length of link CD in cm
DE=36//    length of link DE in cm
EF=12//    length of link EF in cm
FP=36//    length of link FP in cm
Nba=200//   roating speed of link BA IN rpm
wBA=2*PI*200/60//    Angular velocity of BA in rad/s
Vba=wBA*AB/100//    linear velocity of B with
   respect to A in m/s
Vc=2.428//   velocity of c in m/s from diagram 1.32(
   b)
Vd=2.36//     velocity of D in m/s from diagram
   1.32(b)
Ve=1//    velocity of e in m/s from diagram 1.32(b)
Vf=1.42//    velocity of f in m/s from diagram 1.32(
   b)
Vcb=1.3//    velocity of c with respect to b in m/s
   from figure
fBA=Vba^2*100/AB//   radial component of
   acceleration of B with respect to A in m/s^2
fCB=Vcb^2*100/BC//   radial component of
   acceleration of C with respect to B in m/s^2
```

```
fcb=3.52//          radial component of acceleration of C with respect to B in m/s^2 from figure
fC=19//             acceleration of slider in m/s^2 from figure
printf('velocity of c=%.3f m/s\n velocity of d=%.3f m/s\n velocity of e=%.3f m/s\n velocity of f=%.3f m/s\n Acceleration of slider=%f m/s^2',Vc,Vd,Ve,Vf,fC)
```

Scilab code Exa 1.13 angular acceleration

```
//CHAPTER 1 ILLUSRTATION 13 PAGE NO 30
//TITLE:Basic kinematics
//Figure 1.33(a),1.33(b),1.33(c)
clc
clear
PI=3.141
N=120//         speed of the crank OC in rpm
OC=5//          length of link OC in cm
cp=20//         length of link CP in cm
qa=10//         length of link QA in cm
pa=5//          length of link PA in cm
CP=46.9//         velocity of link CP in cm/s
QA=58.3//         velocity of link QA in cm/s
Pa=18.3//         velocity of link PA in cm/s
Vc=2*PI*N*OC/60//     velocity of C in m/s
Cco=Vc^2/OC//         centripetal acceleration of C relative to O in cm/s^2
Cpc=CP^2/cp//          centripetal acceleration of P relative to C in cm/s^2
Caq=QA^2/qa//           centripetal acceleration of A relative to Q in cm/s^2
Cap=Pa^2/pa//            centripetal acceleration of A relative to P in cm/s^2
pp1=530
```

```
a1a=323
a2a=207.5
ACP=pp1/cp//        angular acceleration of link CP
   in rad/s^2
APA=a1a/qa//        angular acceleration of link PA
   in rad/s^2
AAQ=a2a/pa//        angular acceleration of link AQ
   in rad/s^2
printf('angular acceleration of link CP =%.3f rad/s
   ^2\n angular acceleration of link CP=%.3f rad/s
   ^2\n angular acceleration of link CP=%.3f rad/s^2
   ',ACP,APA,AAQ)
```

Chapter 2

TRANSMISSION OF MOTION AND POWER BY BELTS AND PULLEYS

Scilab code Exa 2.1 finding the diameter of the belt

```
//CHAPTER 2 ILLUSRTATION 1 PAGE NO 57
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
    AND PULLEYS
clc
clear
//
    ================================================================
//INPUT DATA
Na=300;//driving shaft running speed in rpm
Nb=400;//driven shaft running speed in rpm
Da=60;//diameter of driving shaft in mm
t=.8;//belt thickness in mm
s=.05;//slip in percentage(5%)
//
    ================================================================
```

```
//calculation
Db=(Da*Na)/Nb;//finding out the diameter of driven shaft without considering the thickness of belt
Db1=(((Da+t)*Na)/Nb)-t///considering the thickness
Db2=(1-s)*(Da+t)*(Na/Nb)-t//considering slip also
//==============================================================================
//output
printf('the value of Db is %3.0f cm',Db)
printf('\nthe value of Db1 is %f cm',Db1)
printf('\nthe value of Db2 is %f cm',Db2)
```

Scilab code Exa 2.2 speed of shafts

```
//CHAPTER 2,ILLUSRTATION 2 PAGE NO 57
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS AND PULLEYS
clc
clear
//==============================================================================
//input
n1=1200//rpm of motor shaft
d1=40//diameter of motor pulley in cm
d2=70//diameter of 1st pulley on the shaft in cm
s=.03//percentage slip(3%)
d3=45//diameter of 2nd pulley
d4=65//diameter of the pulley on the counnter shaft
//==============================================================================
//calculation
n2=n1*d1*(1-s)/d2//rpm of driven shaft
```

```
n3=n2//both the pulleys are mounted on the same
    shaft
n4=n3*(1-s)*d3/d4//rpm of counter shaft

//output
printf('the speed of driven shaft is %f rpm\nthe
    speed of counter shaft is %f rpm',n2,n4)
```

Scilab code Exa 2.3 length of belt

```
//CHAPTER 2 ILLUSTRATION 3 PAGE NO:58
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
    AND PULLEYS
clc
clear
//
    ===========================================

//input
d1=30//diameter of 1st shaft in cm
d2=50//diameter 2nd shaft in cm
pi=3.141
c=500//centre distance between the shafts in cm
//
    ===========================================

//calculation
L1=((d1+d2)*pi/2)+(2*c)+((d1+d2)^2)/(4*c)//lenth of
    cross belt
L2=((d1+d2)*pi/2)+(2*c)+((d1-d2)^2)/(4*c)//lenth of
    open belt
r=L1-L2//remedy
//
    ===========================================
```

```
//OUTPUT
printf('length of cross belt is %3.3fcm \n length of open belt is %3.3f cm \n the length of the belt to be shortened is %3.0f cm',L1,L2,r)
```

Scilab code Exa 2.4 power required

```
//CHAPTER 2,ILLUSTRATION 4 PAGE 59
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS AND PULLEYS
clc
clear
//
//INPUT
D1=.5//            DIAMETER OF 1ST SHAFT IN m
D2=.25//           DIAMETER OF 2nd SHAFT IN m
C=2//              CENTRE DISTANCE IN m
N1=220//           SPEED OF 1st SHAFT
T1=1250//          TENSION ON TIGHT SIDE IN N
U=.25//            COEFFICIENT OF FRICTION
PI=3.141
e=2.71
//
//CALCULATION
L=(D1+D2)*PI/2+((D1+D2)^2/(4*C))+2*C
F=(D1+D2)/(2*C)
ALPHA=asind(F)
THETA=(180+(2*ALPHA))*PI/180//    ANGLE OF CONTACT IN radians
T2=T1/(e^(U*THETA))//             TENSION ON SLACK SIDE IN N
```

```
V=PI*D1*N1/60//                         VELOCITY IN m/s
P=(T1-T2)*V/1000//                      POWER IN kW
//
=====================================================================
//OUTPUT
printf('\nLENGTH OF BELT REQUIRED =%f m',L)
printf('\nANGLE OF CONTACT =%f radians',THETA)
printf('\nPOWER CAN BE TRANSMITTED=%f kW',P)
```

Scilab code Exa 2.5 tension in belt

```
//CHAPTER 2,ILLUSTRATION 5 PAGE 5
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
   AND PULLEYS
clc
clear
//
=====================================================================
//input
n1=100// of driving shaft
n2=240//speed of driven shaft
p=11000//power to be transmitted in watts
c=250//centre distance in cm
d2=60//diameter in cm
b=11.5*10^-2//width of belt in metres
t=1.2*10^-2//thickness in metres
u=.25//co-efficient of friction
pi=3.141
e=2.71
//
=====================================================================
//calculation for open bely drive
```

```
d1=n2*d2/n1
f=(d1-d2)/(2*c)//sin(alpha) for open bely drive
//angle of arc of contact for open belt drive is, theta=180-2*alpha
alpha=asind(f)
teta=(180-(2*alpha))*3.147/180//pi/180 is used to convert into radians
x=(e^(u*teta))//finding out the value of t1/t2
v=pi*d2*10*n2/60//finding out the value of t1-t2
y=p*1000/(v)
t1=(y*x)/(x-1)
Fb=t1/(t*b)/1000
//
//calculation for cross belt drive bely drive
F=(d1+d2)/(2*c)//for cross belt drive bely drive
ALPHA=asind(F)
THETA=(180+(2*ALPHA))*pi/180//pi/180 is used to convert into radians
X=(e^(u*THETA))//finding out the value of t1/t2
V=pi*d2*10*n2/60//finding out the value of t1-t2
Y=p*1000/(V)
T1=(Y*X)/(X-1)
Fb2=T1/(t*b)/1000
//
//output
printf('for a open belt drive:\n')
printf('the tension in  belt is %.3f N\nstress induced is %.3f kN/m^2\n',t1,Fb)
printf('for a cross belt drive:\n')
printf('the tension in belt is %.3f N\nstress induced is %.3f kN/m^2\n',T1,Fb2)
```

Scilab code Exa 2.6 width of belt required

```
//CHAPTER 2,ILLUSTRATION 6 PAGE 61
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS AND PULLEYS
clc
clear
//==============================================================================
//INPUT
D1=80//DIAMETER OF SHAFT IN cm
N1=160//SPEED OF 1ST SHAFT IN rpm
N2=320//SPEED OF 2ND SHAFT IN rpm
C=250//CENTRE DISTANCE IN CM
U=.3//COEFFICIENT OF FRICTION
P=4//POWER IN KILO WATTS
e=2.71
PI=3.141
f=110//STRESS PER cm WIDTH OF BELT
//==============================================================================
//CALCULATION
V=PI*D1*10^-2*N1/60//VELOCITY IN m/s
Y=P*1000/V//Y=T1-T2
D2=D1*N1/N2//DIAMETER OF DRIVEN SHAFT
F=(D1-D2)/(2*C)
ALPHA=asind(F)
THETA=(180-(2*ALPHA))*PI/180//ANGLE OF CONTACT IN radians
X=e^(U*THETA)//VALUE OF T1/T2
T1=X*Y/(X-1)
b=T1/f//WIDTH OF THE BELT REQUIRED
```

```
//
//OUTPUT
printf('THE WIDTH OF THE BELT IS %f cm',b)
```

Scilab code Exa 2.7 power supplied by drum

```
//CHAPTER 2 ILLUSRTATION 7 PAGE NO 62
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS AND PULLEYS
clc
clear
//
//INPUT DATA
m=1000//                                          MASS OF THE CASTING IN kg
PI=3.141
THETA=2.75*2*PI//                                 ANGLE OF CONTACT IN radians
D=.26//                                            DIAMETER OF DRUM IN m
N=24//                                             SPEED OF THE DRUM IN rpm
U=.25//                                            COEFFICIENT OF FRICTION
e=2.71
T1=9810//                                          TENSION ON TIGHTSIDE IN N
//
//CALCULATION
```

```
T2=T1/(e^(U*THETA))//                    tension on slack side of belt in N
W=m*9.81//                               WEIGHT OF CASTING IN N
R=D/2//                                  RADIUS OF DRUM IN m
P=2*PI*N*W*R/60000//                     POWER REQUIRED IN kW
P2=(T1-T2)*PI*D*N/60000//                    POWER SUPPLIED BY DRUM IN kW
//=====================================================================
//OUTPUT
printf('FORCE REQUIRED BY MAN=%f N\n POWER REQUIRED TO RAISE CASTING=%f kW\n POWER SUPPLIED BY DRUM=%f kW\n',T2,P,P2)
```

Scilab code Exa 2.8 power capacity of belt

```
//CHAPTER 2,ILLUSTRATION 8 PAGE 62
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS AND PULLEYS
clc
clear
//INPUT
t=9//THICKNESS IN mm
b=250//WIDTH IN mm
D=90//DIAMETER OF PULLEY IN cm
N=336//SPEED IN rpm
PI=3.141
U=.35//COEFFICIENT FRICTION
e=2.71
THETA=120*PI/180
Fb=2//STRESS IN MPa
```

```
d=1000//DENSITY IN KG/M^3

//CALCULATION
M=b*10^-3*t*10^-3*d//MASS IN KG
V=PI*D*10^-2*N/60//VELOCITY IN m/s
Tc=M*V^2//CENTRIFUGAL TENSION
Tmax=b*t*Fb//MAX TENSION IN N
T1=Tmax-Tc
T2=T1/(e^(U*THETA))
P=(T1-T2)*V/1000

//OUTPUT
printf('THE TENSION ON TIGHT SIDE OF THE BELT IS %f
    N\n',T1)
printf('THE TENSION ON SLACK SIDE OF THE BELT IS %f
    N\n',T2)
printf('CENTRIFUGAL TENSION =%f N\n',Tc)
printf('THE POWER CAPACITY OF BELT IS %f KW\n',P)
```

Scilab code Exa 2.9 thickness of belt

```
//CHAPTER 2,ILLUSTRATION 9 PAGE 63
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
    AND PULLEYS
clc
clear
//INPUT
P=35000//POWER TO BE TRANSMITTED IN WATTS
D=1.5//EFFECTIVE DIAMETER OF PULLEY IN METRES
N=300//SPEED IN rpm
e=2.71
U=.3//COEFFICIENT OF FRICTION
PI=3.141
THETA=(11/24)*360*PI/180//ANGLE OF CONTACT
density=1.1//density of belt material in Mg/m^3
```

```
L=1//in metre
t=9.5//THICKNESS OF BELT IN mm
Fb=2.5//PERMISSIBLE WORK STRESS IN N/mm^2

//CALCULATION
V=PI*D*N/60//VELOCITY IN m/s
X=P/V//X=T1-T2
Y=e^(U*THETA)//Y=T1/T2
T1=X*Y/(Y-1)
Mb=t*density*L/10^3//value of m/b
Tc=Mb*V^2//centrifugal tension/b
Tmaxb=t*Fb//max tension/b
b=T1/(Tmaxb-Tc)//thickness in mm
//output
printf('\nTENSION IN TIGHT SIDE OF THE BELT =%f N',
    T1)
printf('\nTHICKNESS OF THE BELT IS =%f mm',b)
```

Scilab code Exa 2.10 stress developed on tight side of belt

```
//CHAPTER 2,ILLUSTRATION 10 PAGE 64
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
    AND PULLEYS
clc
clear
//INPUT
t=5//THICKNESS OF BELT IN m
PI=3.141
U=.3
e=2.71
THETA=155*PI/180//ANGLE OF CONTACT IN radians
V=30//VELOCITY IN m/s
density=1//in m/cm^3
L=1//LENGTH

```

```
//calculation
Xb=80//              (T1-T2)=80b;so let (T1-T2)/b=Xb
Y=e^(U*THETA)//      LET Y=T1/T2
Zb=80*Y/(Y-1)//      LET T1/b=Zb;BY SOLVING THE ABOVE
   2 EQUATIONS WE WILL GET THIS EXPRESSION
Mb=t*L*density*10^-2// m/b in N
Tcb=Mb*V^2//            centrifugal tension/b
Tmaxb=Zb+Tcb//          MAX TENSION/b
Fb=Tmaxb/t//STRESS INDUCED IN TIGHT BELT

//OUTPUT
printf('THE STRESS DEVELOPED ON THE TIGHT SIDE OF
   BELT=%f N/cm^2',Fb)
```

Scilab code Exa 2.11 speed of the pulley

```
//CHAPTER 2,ILLUSTRATION 11 PAGE 65
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
   AND PULLEYS
clc
clear
//INPUT
C=4.5//        CENTRE DISTANCE IN metres
D1=1.35//      DIAMETER OF LARGER PULLEY IN metres
D2=.9//        DIAMETER OF SMALLER PULLEY IN metres
To=2100//      INITIAL TENSION IN newtons
b=12//         WIDTH OF BELT IN cm
t=12//         THICKNESS OF BELT IN mm
d=1//          DENSITY IN gm/cm^3
U=.3//         COEFFICIENT OF FRICTION
L=1//          length in metres
PI=3.141
e=2.71

//CALCULATION
```

```
M=b*t*d*L*10^-2//                    mass of belt per
    metre length in KG
V=(To/3/M)^.5//                      VELOCITY OF FOR MAX
    POWER TO BE TRANSMITTED IN m/s
Tc=M*V^2//                           CENTRIFUGAL TENSION
    IN newtons
//                                   LET (T1+T2)=X
X=2*To-2*Tc   //                     THE VALUE OF (T1+T2)
F=(D1-D2)/(2*C)
ALPHA=asind(F)
THETA=(180-(2*ALPHA))*PI/180//  ANGLE OF CONTACT IN
     radians
//                                   LET T1/T2=Y
Y=e^(U*THETA)//                      THE VALUE OF T1/T2
T1=X*Y/(Y+1)//                       BY SOLVING X AND Y
    WE WILL GET THIS EQN
T2=X-T1
P=(T1-T2)*V/1000//                      MAX POWER
    TRANSMITTED IN kilowatts
N1=V*60/(PI*D1)//                          SPEED OF LARGER
    PULLEY IN rpm
N2=V*60/(PI*D2)//                          SPEED OF SMALLER
     PULLEY IN rpm
//OUTPUT
printf('\n MAX POWER TO BE TRANSMITTED =%f KW',P)
printf('\n SPEED OF THE LARGER PULLEY =%f rpm',N1)
printf('\n SPEED OF THE SMALLER PULLEY =%f rpm',N2)
```

Scilab code Exa 2.12 efficiency of drive

```
//CHAPTER 2,ILLUSTRATION 12 PAGE 66
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
    AND PULLEYS
clc
clear
```

```
//
//INPUT
PI=3.141
e=2.71
D1=1.20//                    DIAMETER OF DRIVING SHAFT IN m
D2=.50//                     DIAMETER OF DRIVEN SHAFT IN m
C=4//                        CENTRE DISTANCE BETWEEN THE SHAFTS IN m
M=.9//                       MASS OF BELT PER METRE LENGTH IN kg
Tmax=2000//                  MAX TENSION IN N
U=.3//                       COEFFICIENT OF FRICTION
N1=200//                     SPEED  OF DRIVING SHAFT IN rpm
N2=450//                     SPEED OF DRIVEN SHAFT IN rpm
//
//CALCULATION
V=PI*D1*N1/60//              VELOCITY OF BELT IN m/s
Tc=M*V^2//                   CENTRIFUGAL TENSION IN N
T1=Tmax-Tc//                 TENSION ON TIGHTSIDE IN N
F=(D1-D2)/(2*C)
ALPHA=asind(F)
THETA=(180-(2*ALPHA))*PI/180//    ANGLE OF CONTACT IN radians
T2=T1/(e^(U*THETA))//             TENSION ON SLACK SIDE IN N
TL=(T1-T2)*D1/2//                 TORQUE ON THE SHAFT OF LARGER PULLEY IN N-m
TS=(T1-T2)*D2/2//                 TORQUE ON THE SHAFT OF SMALLER PULLEY IN N-m
P=(T1-T2)*V/1000//                POWER TRANSMITTED IN kW
```

```
Pi=2*PI*N1*TL/60000//                    INPUT POWER
Po=2*PI*N2*TS/60000//                    OUTPUT POWER
Pl=Pi-Po//                               POWER LOST DUE TO FRICTION IN kW
n=Po/Pi*100//                            EFFICIENCY OF DRIVE IN %
//==================================================================
//OUTPUT
printf('\nTORQUE ON LARGER SHAFT =%f N-m',TL)
printf('\nTORQUE ON SMALLER SHAFT =%f N-m',TS)
printf('\nPOWER TRANSMITTED =%f kW',P)
printf('\nPOWER LOST DUE TO FRICTION =%f kW',Pl)
printf('\nEFFICIENCY OF DRINE =%f percentage',n)
```

Scilab code Exa 2.13 no of belts required

```
//CHAPTER 2,ILLUSTRATION 13 PAGE 67
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS AND PULLEYS
clc
clear
//==================================================================
//INPUT
PI=3.141
e=2.71
P=90//                              POWER OF A COMPRESSOR IN kW
N2=250//                            SPEED OF DRIVEN SHAFT IN rpm
N1=750//                            SPEED OF DRIVER SHAFT IN rpm
```

```
D2=1//                    DIAMETER OF DRIVEN SHAFT IN m
C=1.75//                  CENTRE DISTANCE IN m
V=1600/60//               VELOCITY IN m/s
a=375//                   CROSECTIONAL AREA IN mm^2
density=1000//            BELT DENSITY IN kg/m^3
L=1//                     length to be considered
Fb=2.5//                  STRESSS INDUCED IN MPa
beeta=35/2//              THE GROOVE ANGLE OF PULLEY
U=.25//                   COEFFICIENT OF FRICTION
//==========================================================
//CALCULATION
D1=N2*D2/N1//             DIAMETER OF DRIVING SHAFT IN m
m=a*density*10^-6*L//     MASS OF THE BELT IN kg
Tmax=a*Fb//               MAX TENSION IN N
Tc=m*V^2//                CENTRIFUGAL TENSION IN N
T1=Tmax-Tc//              TENSION ON TIGHTSIDE OF BELT IN N
F=(D2-D1)/(2*C)
ALPHA=asind(F)
THETA=(180-(2*ALPHA))*PI/180//   ANGLE OF CONTACT IN radians
T2=T1/(e^(U*THETA/sind(beeta)))//TENSION ON SLACKSIDE IN N
P2=(T1-T2)*V/1000//              POWER TRANSMITTED PER BELT kW
N=P/P2//                          NO OF V-BELTS
N3=N+1
//==========================================================
//OUTPUT
printf('NO OF BELTS REQUIRED TO TRANSMIT POWER=%f
```

```
APPROXIMATELY=%d\n',N,N3)
```

Scilab code Exa 2.14 initial rope tension

```
//CHAPTER 2,ILLUSTRATION 14 PAGE 68
//TITLE:TRANSMISSION OF MOTION AND POWER BY BELTS
    AND PULLEYS

clc
clear
//
    ==========================================================================
//INPUT
PI=3.141
e=2.71
P=75//                  POWER IN kW
D=1.5//                 DIAMETER OF PULLEY IN m
U=.3//                  COEFFICIENT OF FRICTION
beeta=45/2//            GROOVE ANGLE
THETA=160*PI/180//      ANGLE OF CONTACT IN radians
m=.6//                  MASS OF BELT IN kg/m
Tmax=800//              MAX TENSION IN N
N=200//                 SPEED OF SHAFT IN rpm
//
    ==========================================================================
//calculation
V=PI*D*N/60//                   VELOCITY OF ROPE IN m/s
Tc=m*V^2//                      CENTRIFUGAL TENSION IN N
T1=Tmax-Tc//                            TENSION ON TIGHT
    SIDE IN N
T2=T1/(e^(U*THETA/sind(beeta)))//TENSION ON
    SLACKSIDE IN N
P2=(T1-T2)*V/1000//                     POWER TRANSMITTED
```

```
PER BELT kW
No=P/P2//NO OF V-BELTS
N3=No+1//ROUNDING OFF
To=(T1+T2+Tc*2)/2//INITIAL TENSION
//====================================================================
//OUTPUT
printf('NO OF BELTS REQUIRED TO TRANSMIT POWER=%f APPROXIMATELY=%d\n',No,N3)
printf('INITIAL ROPE TENSION=%f N',To)
```

Chapter 3

FRICTION

Scilab code Exa 3.1 finding out the coefficient of friction

```
//CHAPTER 3 ILLUSRTATION 1 PAGE NO 102
//TITLE:FRICTION
//FIRURE 3.16(a),3.16(b)
clc
clear
//

//INPUT DATA
P1=180//                                PULL APPLIED TO THE BODY IN NEWTONS
theta=30//                              ANGLE AT WHICH P IS ACTING IN DEGREES
P2=220//                                PUSH APPLIED TO THE BODY IN NEWTONS
//Rn=                                   NORMAL REACTION
//F=                                    FORCE OF FRICTION IN NEWTONS
//U=                                    COEFFICIENT OF FRICTION
//W=                                    WEIGHT OF THE BODY
```

```
IN NEWTON
//==========================================================================
//CALCULATION
F1=P1*cosd(theta)//                    RESOLVING FORCES HORIZONTALLY FROM 3.16(a)
F2=P2*cosd(theta)//                    RESOLVING FORCES HORIZONTALLY FROM 3.16(b)
//                                     RESOLVING FORCES VERTICALLY  Rn1=W-P1*sind(theta) from 3.16(a)
//                                     RESOLVING FORCES VERTICALLY  Rn2=W+P1*sind(theta) from 3.16(b)
//                                     USING THE RELATION F1=U*Rn1    &     F2=U*Rn2  AND SOLVING FOR W BY DIVIDING THESE TWO EQUATIONS
X=F1/F2//                              THIS IS THE VALUE OF   Rn1/Rn2
Y1=P1*sind(theta)
Y2=P2*sind(theta)
W=(Y2*X+Y1)/(1-X)//                      BY SOLVING ABOVE 3 EQUATIONS
U=F1/(W-P1*sind(theta))//                COEFFICIENT OF FRICTION
//==========================================================================
//OUTPUT
printf('WEIGHT OF THE BODY =%.3fN\nTHE COEFFICIENT OF FRICTION =%.3f',W,U)
```

Scilab code Exa 3.2 DISTANCE ALONG THE INCLINED PLANE

```
//CHAPTER 3 ILLUSRTATION 2 PAGE NO 103
//TITLE:FRICTION
```

```
//FIRURE 3.17
clc
clear
//
//INPUT DATA
THETA=45//                              ANGLE OF INCLINATION IN DEGREES
g=9.81//                                ACCELERATION DUE TO GRAVITY IN N/mm^2
U=.1//                                  COEFFICIENT FRICTION
//Rn=NORMAL REACTION
//M=MASS IN NEWTONS
//f=ACCELERATION OF THE BODY
u=0//                                   INITIAL VELOCITY
V=10//                                  FINAL VELOCITY IN m/s^2
//
//CALCULATION
//CONSIDER THE EQUILIBRIUM OF FORCES PERPENDICULAR TO THE PLANE
//Rn=Mgcos(THETA)
//CONSIDER THE EQUILIBRIUM OF FORCES ALONG THE PLANE
//Mgsin(THETA)-U*Rn=M*f.............BY SOLVING THESE 2 EQUATIONS
f=g*sind(THETA)-U*g*cosd(THETA)
s=(V^2-u^2)/(2*f)//                              DISTANCE ALONG THE PLANE IN metres
//
//OUTPUT
printf('DISTANCE ALONG THE INCLINED PLANE=%3.3f m',s)
```

Scilab code Exa 3.3 workdone

```
//CHAPTER 3 ILLUSRTATION 3 PAGE NO 104
//TITLE:FRICTION
//FIRURE 3.18
clc
clear
//===========================================================================
//INPUT DATA
W=500//                    WEGHT IN NEWTONS
THETA=30//                 ANGLE OF INCLINATION IN DEGRESS
U=0.2//                    COEFFICIENT FRICTION
S=15//                     DISTANCE IN metres
//===========================================================================
Rn=W*cosd(THETA)//         NORMAL REACTION IN NEWTONS
P=W*sind(THETA)+U*Rn//     PUSHING FORCE ALONG THE DIRECTION OF MOTION
w=P*S
//===========================================================================
//OUTPUT
printf('WORK DONE BY THE FORCE=%3.3f N-m',w)
```

Scilab code Exa 3.4 FINDING OUT COEFFICIENT OF FRICTION

```
//CHAPTER 3 ILLUSRTATION 4 PAGE NO 104
```

```
//TITLE:FRICTION
//FIRURE 3.19(a) & 3.19(b)
clc
clear
//==================================================================
//INPUT DATA
P1=2000//              FORCE ACTING UPWARDS WHEN ANGLE =15 degrees IN NEWTONS
P2=2300//              FORCE ACTING UPWARDS WHEN ANGLE =20 degrees IN NEWTONS
THETA1=15//            ANGLE OF INCLINATION IN 3.19(a)
THETA2=20//            ANGLE OF INCLINATION IN 3.19(b)
//F1=                  FORCE OF FRICTION IN 3.19(a)
//Rn1=                 NORMAL REACTION IN 3.19(a)
//F2=                  FORCE OF FRICTION IN 3.19(b)
//Rn2=                 NORMAL REACTION IN 3.19(b)
//U=                    COEFFICIENT OF FRICTION
//==================================================================
//CALCULATION
//P1=F1+Rn1                  RESOLVING THE FORCES ALONG THE PLANE
//Rn1=W*cosd(THETA1)....NORMAL REACTION IN 3.19(a)
//F1=U*Rn1
//BY SOLVING ABOVE EQUATIONS P1=W(U*cosd(THETA1)+sind(THETA1))------------------------1
//P2=F2+Rn2                  RESOLVING THE FORCES PERPENDICULAR TO THE PLANE
//Rn2=W*cosd(THETA2)....NORMAL REACTION IN 3.19(b)
//F2=U*Rn2
//BY SOLVING ABOVE EQUATIONS P2=W(U*cosd(THETA2)+sind(THETA2))------------------------2
//BY SOLVING EQUATIONS 1 AND 2
X=P2/P1
U=(sind(THETA2)-(X*sind(THETA1)))/((X*cosd(THETA1)-
```

```
    cosd(THETA2)))//          COEFFICIENT OF FRICTION
W=P1/(U*cosd(THETA1)+sind(THETA1))
//
//OUTPUT
//printf('%f',X)
printf('COEFFICIENT OF FRICTION=%3.3f\n WEIGHT OF
    THE BODY=%3.3f N',U,W)
```

Scilab code Exa 3.5 EFFORT NEED TO APPLIED

```
//CHAPTER 3 ILLUSRTATION 5 PAGE NO 105
//TITLE:FRICTION
clc
clear
//
//INPUT DATA
d=5//                           DIAMETER OF SCREW JACK IN
    cm
p=1.25//                        PITCH IN cm
l=50//                          LENGTH IN cm
U=.1//                          COEFFICIENT OF FRICTION
W=20000//                       LOAD IN NEWTONS
PI=3.147
//
//CALCULATION
ALPHA=atand(p/(PI*d))
PY=atand(U)
P=W*tand(ALPHA+PY)
P1=P*d/(2*l)
```

```
//
//OUTPUT
printf('THE AMOUNT OF EFFORT NEED TO APPLY =%3.3f N'
    ,P1)
```

Scilab code Exa 3.6 EFFICIENCY OF THE MACHINE

```
//CHAPTER 3 ILLUSRTATION 6 PAGE NO 106
//TITLE:FRICTION
clc
clear
//
//INPUT DATA
d=50//                    DIAMETER OF SCREW IN mm
p=12.5//                  PITCH IN mm
U=0.13//                  COEFFICIENT OF FRICTION
W=25000//                 LOAD IN mm
PI=3.147
//
//CALCULATION
ALPHA=atand(p/(PI*d))
PY=atand(U)
P=W*tand(ALPHA+PY)//          FORCE REQUIRED TO RAISE
    THE LOAD IN N
T1=P*d/2//                    TORQUE REQUIRED IN Nm
P1=W*tand(PY-ALPHA)//         FORCE REQUIRED TO LOWER
    THE SCREW IN N
T2=P1*d/2//                   TORQUE IN N
X=T1/T2//                      RATIOS REQUIRED
```

```
n=tand(ALPHA/(ALPHA+PY))//     EFFICIENCY
//
printf('RATIO OF THE TORQUE REQUIRED TO RAISE THE LOAD,TO THE TORQUE REQUIRED TO LOWER THE LOAD =%.3f',X)
```

Scilab code Exa 3.7 EFFICIENCY OF MACHINE

```
//CHAPTER 3 ILLUSRTATION 7 PAGE NO 107
//TITLE:FRICTION
clc
clear
//
//INPUT DATA
d=39//                    DIAMETER OF THREAD IN mm
p=13//                    PITCH IN mm
U=0.1//                   COEFFICIENT OF FRICTION
W=2500//                  LOAD IN mm
PI=3.147
//
//CALCULATION
ALPHA=atand(p/(PI*d))
PY=atand(U)
P=W*tand(ALPHA+PY)//           FORCE IN N
T1=P*d/2//                     TORQUE REQUIRED IN Nm
T=2*T1//                        TORQUE REQUIRED ON THE COUPLING ROD IN Nm
K=2*p//                        DISTANCE TRAVELLED FOR ONE REVOLUTION
```

```
N=20.8/K//                          NO OF REVOLUTIONS
    REQUIRED
w=2*PI*N*T/100//                        WORKDONE BY TORQUE
w1=w*(7500-2500)/2500//         WORKDONE TO INCREASE
    THE LOAD FROM 2500N TO 7500N
n=tand(ALPHA)/tand(ALPHA+PY)//     EFFICIENCY
//
    ================================================================================

//OUTPUT
printf('workdone against a steady load of 2500N=%3.3
    f N\n workdone if the load is increased from 2500
    N to 7500N=%3.3f N\n efficiency=%.3f',w,w1,n)
```

Scilab code Exa 3.8 NO OF TEETH ON PINION

```
//CHAPTER 3 ILLUSRTATION 8 PAGE NO 107
//TITLE:FRICTION
clc
clear
//
    ================================================================================

//INPUT DATA
W=50000//                               WEIGHT OF THE
    SLUICE GATE IN NEWTON
P=40000//                               POWER IN WATTS
N=580//                                 MAX MOTOR RUNNING
    SPEEED IN rpm
d=12.5//                                DIAMETER OF THE
    SCREW IN cm
p=2.5//                                 PITCH IN cm
PI=3.147
U1=.08//                                 COEFFICIENT OF
    FRICTION for SCREW
```

```
U2=.1//                                C.O.F BETWEEN GATES AND SCREW
Np=2000000//                           NORMAL PRESSURE IN NEWTON
Fl=.15//                               FRICTION LOSS
n=1-Fl//                               EFFICIENCY
ng=80//                                NO OF TEETH ON GEAR
//
//CALCULATION
TV=W+U2*Np//                           TOTAL VERTICAL HEAD IN NEWTON
ALPHA=atand(p/(PI*d))//
PY=atand(U1)//
P1=TV*tand(ALPHA+PY)//                 FORCE IN N
T=P1*d/2/100//                         TORQUE IN N-m
Ng=60000*n*P*10^-3/(2*PI*T)//          SPEED OF GEAR IN rpm
np=Ng*ng/N//                           NO OF TEETH ON PINION
//
//OUTPUT
printf('NO OF TEETH ON PINION =%.2f say %d',np,np+1)
```

Scilab code Exa 3.9 TO FIND THE DIAMETER OF HAND WHEEL

```
//CHAPTER 3 ILLUSRTATION 9 PAGE NO 108
//TITLE:FRICTION
clc
clear
//
```

```
//INPUT DATA
d=5//                          MEAN DIAMETER OF SCREW
    IN cm
p=1.25//                       PITCH IN cm
W=10000//                      LOAD AVAILABLE IN
    NEWTONS
dc=6//                         MEAN DIAMETER OF
    COLLAR IN cm
U=.15//                        COEFFICIENT OF
    FRICTION OF SCREW
Uc=.18//                       COEFFICIENT OF
    FRICTION OF COLLAR
P1=100//                       TANGENTIAL FORCE
    APPLIED IN NEWTON
PI=3.147
//
    ==================================================================
//CALCULATION
ALPHA=atand(p/(PI*d))//
PY=atand(U)//
T1=W*d/2*tand(ALPHA+PY)/100//          TORQUE ON
    SCREW IN NEWTON
Tc=Uc*W*dc/2/100//                        TORQUE ON
    COLLAR IN NEWTON
T=T1+Tc//                              TOTAL TORQUE
D=2*T/P1/2*100//                          DIAMETER OF
    HAND WHEEL IN cm
//
    ==================================================================
//OUTPUT
printf('SUITABLE DIAMETER OF HAND WHEEL =%3.3f cm',D
    )
```

Scilab code Exa 3.10 FORCE REQUIRED

```
//CHAPTER 3 ILLUSRTATION 10 PAGE NO 108
//TITLE:FRICTION
clc
clear
//==============================================================
//INPUT DATA
PI=3.147
d=2.5//                     MEAN DIA OF BOLT IN cm
p=.6//                      PITCH IN cm
beeta=55/2//                VEE ANGLE
dc=4//                      DIA OF COLLAR IN cm
U=.1//                        COEFFICIENT OF FRICTION
    OF BOLT
Uc=.18//                       COEFFICIENT OF
   FRICTION OF COLLAR
W=6500//                      LOAD ON BOLT IN NEWTONS
L=38//                        LENGTH OF SPANNER
//==============================================================
//CALCULATION
//LET X=tan(py)/tan(beeta)
//y=tan(ALPHA)*X
PY=atand(U)
ALPHA=atand(p/(PI*d))
X=tand(PY)/cosd(beeta)
Y=tand(ALPHA)
T1=W*d/2*10^-2*(X+Y)/(1-(X*Y))//              TORQUE
   IN SCREW IN N-m
Tc=Uc*W*dc/2*10^-2//                          TORQUE
```

```
ON BEARING SERVICES IN N-m
T=T1+Tc//                                    TOTAL TORQUE
P1=T/L*100//                                 FORCE REQUIRED BY @ THE END OF SPANNER
//==============================================================================
//OUTPUT
printf('FORCE REQUIRED @ THE END OF SPANNER=%3.3f N',P1)
```

Scilab code Exa 3.11 POWER LOST IN FRICTION

```
//CHAPTER 3 ILLUSRTATION 11 PAGE NO 109
//TITLE:FRICTION
clc
clear
//==============================================================================
//INPUT DATA
d1=15//                                      DIAMETER OF VERTICAL SHAFT IN cm
N=100//                                      SPEED OF THE MOTOR rpm
W=20000//                                    LOAD AVILABLE IN N
U=.05//                                      COEFFICIENT OF FRICTION
PI=3.147
//==============================================================================
T=2/3*U*W*d1/2//                             FRICTIONAL
```

```
    TORQUE IN N-m
PL=2*PI*N*T/100/60//                                  POWER
    LOST IN FRICTION IN WATTS
//
    ========================================================
//OUTPUT
printf('POWER LOST IN FRICTION=%3.3f watts',PL)
```

Scilab code Exa 3.12 NO OF COLLARS REQUIRED

```
//CHAPTER 3 ILLUSRTATION 12 PAGE NO 109
//TITLE:FRICTION
clc
clear
//
    ========================================================
//INPUT DATA
PI=3.147
d2=.30//                               DIAMETER OF
    SHAFT IN m
W=200000//                             LOAD AVAILABLE
    IN NEWTONS
N=75//                                 SPEED IN rpm
U=.05//                                COEFFICIENT OF
    FRICTION
p=300000//                             PRESSURE
    AVAILABLE IN N/m^2
P=16200//                              POWER LOST DUE
    TO FRICTION IN WATTS
//
    ========================================================
//CaLCULATION
```

```
T=P*60/2/PI/N//                       TORQUE INDUCED IN THE SHFT IN N-m
//LET X=(r1^3-r2^3)/(r1^2-r2^2)
X=(3/2*T/U/W)
r2=.15//                              SINCE d2=.30 m
c=r2^2-(X*r2)
b= r2-X
a= 1
r1=( -b+ sqrt (b^2 -4*a*c ))/(2* a);//      VALUE OF r1 IN m
d1=2*r1*100//                                d1 IN cm
n=W/(PI*p*(r1^2-r2^2))
//
//OUTPUT
printf('\nEXTERNAL DIAMETER OF SHAFT =%3.3f cm\nNO OF COLLARS REQUIRED =%.3f or %.0f',d1,n,n+1)
```

Scilab code Exa 3.13 POWER ABSORBED IN FRICTION

```
//CHAPTER 3 ILLUSRTATION 13 PAGE NO 111
//TITLE:FRICTION
clc
clear
//
//INPUT DATA
PI=3.147
W=20000//                                LOAD IN NEWTONS
ALPHA=120/2//                            CONE ANGLE IN DEGREES
p=350000//                               INTENSITY
```

```
OF PRESSURE
U=.06
N=120//                                          SPEED OF THE SHAFT IN rpm
//d1=3d2
//r1=3r2
//
//CALCULATION
//LET K=d1/d2
k=3
Z=W/((k^2-1)*PI*p)
r2=Z^.5//                                        INTERNAL RADIUS IN m
r1=3*r2
T=2*U*W*(r1^3-r2^3)/(3*sind(60)*(r1^2-r2^2))//total frictional torque in N
P=2*PI*N*T/60000//                               power absorbed in friction in kW
//
printf('\nTHE INTERNAL DIAMETER OF SHAFT =%3.3f cm\nTHE EXTERNAL DIAMETER OF SHAFT =%3.3f cm\nPOWER ABSORBED IN FRICTION =%.3f kW',r2*100,r1*100,P)
```

Scilab code Exa 3.14 FINDING Radii

```
//CHAPTER 3 ILLUSRTATION 14 PAGE NO 111
//TITLE:FRICTION
clc
clear
//
```

```
//INPUT DATA
PI=3.147
P=10000//                                        POWER TRRANSMITTED BY CLUTCH IN WATTS
N=3000//                                         SPEED IN rpm
p=.09//                                          AXIAL PRESSURE IN N/mm^2
//d1=1.4d2                                       RELATION BETWEEN DIAMETERS
K=1.4//                                          D1/D2
n=2
U=.3//                                           COEFFICIENT OF FRICTION
//==========================================================================
T=P*60000/1000/(2*PI*N)// ASSUMING UNIFORM WEAR                TORQUE IN N-m
r2=(T*2/(n*U*2*PI*p*10^6*(K-1)*(K+1)))^(1/3)//                  INTERNAL RADIUS

//==========================================================================
printf('THE INTERNAL RADIUS =%f cm\n THE EXTERNAL RADIUS =%f cm',r2*100,K*r2*100)
```

Scilab code Exa 3.15 MAX AXIAL INTENSITY OF PRESSURE

```
//CHAPTER 3 ILLUSRTATION 14 PAGE NO 111
//TITLE:FRICTION
clc
//
clear
```

```
//
//INPUT DATA
PI=3.147
n1=3//                          NO OF DICS ON DRIVING SHAFTS
n2=2//                          NO OF DICS ON DRIVEN SHAFTS
d1=30//                         DIAMETER OF DRIVING SHAFT IN cm
d2=15//                         DIAMETER OF DRIVEN SHAFT IN cm
r1=d1/2
r2=d2/2
U=.3//                          COEFFICIENT FRICTION
P=30000//                       TANSMITTING POWER IN WATTS
N=1800//                        SPEED IN rpm
//
//CALCULATION
n=n1+n2-1//                     NO OF PAIRS OF CONTACT SURFACES
T=P*60000/(2*PI*N)//            TORQUE IN N-m
W=2*T/(n*U*(r1+r2)*10)//           LOAD IN N
k=W/(2*PI*(r1-r2))
p=k/r2/100//                          MAX AXIAL INTENSITY OF PRESSURE IN N/mm^2
//
// OUTPUT
printf('MAX AXIAL INTENSITY OF PRESSURE =%f N/mm^2',p)
```

Chapter 4

Gears and Gear Drivers

Scilab code Exa 4.1 Length of arc of contact

```
//Chapter-4, Illustration 1, Page 133
//Title: Gears and Gear Drivers
//==============================================================================

clc
clear

//INPUT DATA
TA=48;//Wheel A teeth
TB=30;//Wheel B teeth
m=5;//Module pitch in mm
phi=20;//Pressure angle in degrees
add=m;//Addendum in mm

//CALCULATIONS
R=(m*TA)/2;//Pitch circle radius of wheel A in mm
RA=R+add;//Radius of addendum circle of wheel A in mm
r=(m*TB)/2;//Pitch circle radius of wheel B in mm
rA=r+add;//Radius of addendum circle of wheel B in
```

```
mm
lp=(sqrt((RA^2)-((R^2)*(cosd(phi)^2))))+(sqrt((rA^2)-((r^2)*(cosd(phi)^2))))-((R+r)*sind(phi));//Length of path of contact in mm
la=lp/cosd(phi);//Length of arc of contact in mm

//OUTPUT
mprintf('Length of arc of contact is %3.1f mm',la)








//=================================END OF PROGRAM==============================================
```

Scilab code Exa 4.2 Addendum of wheel

```
//Chapter-4, Illustration 2, Page 133
//Title: Gears and Gear Drivers
//==============================================================================================

clc
clear

//INPUT DATA
TA=40;//Wheel A teeth
TB=TA;//Wheel B teeth
m=6;//Module pitch in mm
phi=20;//Pressure angle in degrees
pi=3.141
```

```
x=1.75;//Ratio of length of arc of contact to circular pitch

//CALCULATIONS
Cp=m*pi;//Circular pitch in mm
R=(m*TA)/2;//Pitch circle radius of wheel A in mm
r=R;//Pitch circle radius of wheel B in mm
la=x*Cp;//Length of arc of contact in mm
lp=la*cosd(phi);//Length of path of contact in mm
RA=sqrt((((lp/2)+(R*sind(phi)))^2)+((R^2)*(cosd(phi))^2));//Radius of addendum circle of each wheel in mm
add=RA-R;//Addendum in mm

//OUTPUT
mprintf('Addendum of wheel is %3.3f mm',add)










//==========END OF PROGRAM==========
```

Scilab code Exa 4.3 Length of arc of contact

```
//Chapter-4, Illustration 3, Page 134
//Title: Gears and Gear Drivers
//==========
```

```
clc
clear

//INPUT DATA
TA=48;//Gear teeth
TB=24;//Pinion teeth
m=6;//Module in mm
phi=20;//Pressure angle in degrees

//CALCULATIONS
r=(m*TB)/2;//Pitch circle radius of pinion in mm
R=(m*TA)/2;//Pitch circle radius of gear in mm
RA=sqrt(((((r*sind(phi))/2)+(R*sind(phi)))^2)+((R^2)
    *(cosd(phi))^2));//Radius of addendum circle of
    gear in mm
rA=sqrt(((((R*sind(phi))/2)+(r*sind(phi)))^2)+((r^2)
    *(cosd(phi))^2));//Radius of addendum circle of
    pinion in mm
addp=rA-r;//Addendum for pinion in mm
addg=RA-R;//Addendum for gear in mm
lp=((R+r)*sind(phi))/2;//Length of path of contact
    in mm
la=lp/cosd(phi);//Length of arc of contact in mm

//OUTPUT
mprintf('Addendum for pinion is %3.3f mm \n Addendum
     for gear is %3.2f mm \n Length of arc of contact
     is %3.3f mm',addp,addg,la)
```

```
//==================================================END OF PROGRAM==================================================================
```

Scilab code Exa 4.4 Velocity ratio

```
//Chapter-4, Illustration 4, Page 135
//Title: Gears and Gear Drivers
//=============================================================================================================================================

clc
clear

//INPUT DATA
x=3.5;//Ratio of teeth of wheels
C=1.2;//Centre distance between axes in m
DP=4.4;//Diametrical pitch in cm

//CALCULATIONS
D=2*C*100;//Sum of diameters of wheels in cm
T=D*DP;//Sum of teeth of wheels
TB1=T/(x+1);//Teeth of wheel B
TB=floor(TB1);//Teeth of whhel B
TA=x*TB;//Teeth of wheel A
DA=TA/DP;//Diametral pitch of gear A in cm
DB=TB/DP;//Diametral pitch of gear B in cm
Ce=(DA+DB)/2;//Exact centre distance between shafts
   in cm
TB2=ceil(TB1);//Teeth of wheel B
TA2=T-TB2;//Teeth of wheel A
VR=TA2/TB2;//Velocity ratio

//OUTPUT
mprintf('Number of teeth on wheel A is %3.0f \n
   Number of teeth on wheel B is %3.0f \n Exact
```

```
centre distance is %3.3f cm \n If centre distance
 is %3.1f m then \n Velocity ratio is %3.4f',TA,
TB,Ce,C,VR)








//===================================END OF PROGRAM
  ==================================================
```

Scilab code Exa 4.5 Power transmitted

```
//Chapter-4, Illustration 5, Page 136
//Title: Gears and Gear Drivers
//
  ==========================================================================

clc
clear

//INPUT DATA
C=600;//Distance between shafts in mm
Cp=30;//Circular pitch in mm
NA=200;//Speed of wheel A in rpm
NB=600;//Speed of wheel B in rpm
F=18;//Tangential pressure in kN
pi=3.141

//CALCULATIONS
a=Cp/(pi*10);//Ratio of pitch diameter of wheel A to
    teeth of wheel A in cm
```

```
b=Cp/(pi*10);//Ratio of pitch diameter of wheel B to teeth of wheel B in cm
T=(2*C)/(a*10);//Sum of teeth of wheels
r=NB/NA;//Ratio of teeth of wheels
TB=T/(r+1);//Teeth of wheel B
TB1=ceil(TB);//Teeth of wheel B
TA=TB1*r;//Teeth of wheel A
DA=a*TA;//Pitch diameter of wheel A in cm
DB=b*TB1;//Pitch diameter of wheel B in cm
CPA=(pi*DA)/TA;//Circular pitch of gear A in cm
CPB=(pi*DB)/TB1;//Circular pitch of gear B in cm
C1=(DA+DB)*10/2;//Exact centre distance in mm
P=(F*1000*pi*DA*NA)/(60*1000*100);//Power transmitted in kW

//OUTPUT
mprintf('Number of teeth on wheel A is %3.0f \n Number of teeth on wheel B is %3.0f \n Pitch diameter of wheel A is %3.2f cm \n Pitch diameter of wheel B is %3.3f cm \n Circular pitch of wheel A is %3.4f cm \n Circular pitch of wheel B is %3.4f cm \n Exact centre distance between shafts is %3.2f mm \n Power transmitted is %3.3f kW',TA,TB1,DA,DB,CPA,CPB,C1,P)









//=================================================END OF PROGRAM=====================================================
```

Scilab code Exa 4.6 Number of teeth on gear

```
//Chapter-4, Illustration 6, Page 137
//Title: Gears and Gear Drivers
//=============================================================================

clc
clear

//INPUT DATA
r=16;//Speed ratio
mA=4;//Module of gear A in mm
mB=mA;//Module of gear B in mm
mC=2.5;//Mosule of gear C in mm
mD=mC;//Module of gear D in mm
C=150;//Distance between shafts in mm

//CALCULATIONS
t=sqrt(r);//Ratio of teeth
T1=(C*2)/mA;//Sum of teeth of wheels A and B
T2=(C*2)/mC;//Sum of teeth of wheels C and D
TA=T1/(t+1);//Teeth of gear A
TB=T1-TA;//Teeth of gear B
TC=T2/(t+1);//Teeth of gear C
TD=T2-TC;//Teeth of gear D

//OUTPUT
mprintf('Number of teeth on gear A is %3.0f \n
    Number of teeth on gear B is %3.0f \n Number of
    teeth on gear C is %3.0f \n Number of teeth on
    gear D is %3.0f',TA,TB,TC,TD)
```

```
//==================================================END OF PROGRAM
    ======================================================================
```

Scilab code Exa 4.7 noof teeth on gears

```
//Chapter-4, Illustration 7, Page 138
//Title: Gears and Gear Drivers
//
    ============================================================================

clc
clear

//INPUT DATA
N=4.5;//No. of turns

//CALCULATIONS
Vh=N/2;//Velocity ratio of main spring spindle to
    hour hand spindle
Vm=12;//Velocity ratio of minute hand spindle to
    hour hand spindle
T1=8//     assumed no of teeth on gear 1
T2=32//    assumed no of teeth on gear 2
T3=(T1+T2)/4//        no of teeth on gear 3
T4=(T1+T2)-T3// no of teeth on gear 4
printf('no of teeth on gear 1=%d\n no of teeth on
    gear 2=%d\n no of teeth on gear 3=%d\n no of
    teeth on gear 4=%d',T1,T2,T3,T4)
```

Scilab code Exa 4.8 Speed of wheel

```
//Chapter-4, Illustration 8, Page 139
//Title: Gears and Gear Drivers
//=============================================================================

clc
clear

//Input data
Tb=70;//Teeth of wheel B
Tc=25;//Teeth of wheel C
Td=80;//Teeth of wheel D
Na=-100;//Speed of arm A in clockwise in rpm
y=-100//Arm A rotates at 100 rpm clockwise

//Calculations
Te=(Tc+Td-Tb);//Teeth of wheel E
x=(y/0.5)
Nc=(y-(Td*x)/Tc);//Speed of wheel C in rpm

//Output
mprintf('Speed of wheel C is %3.0f rpm \n Direction of wheel C is anti-clockwise',Nc)










//==================================END OF PROGRAM==================================
```

Scilab code Exa 4.9 Speed of wheels

```
//Chapter-4, Illustration 9, Page 140
//Title: Gears and Gear Drivers
//=============================================================================

clc
clear

//Input data
Tb=25;//Teeth of wheel B
Tc=40;//Teeth of wheel C
Td=10;//Teeth of wheel D
Te=25;//Teeth of wheel E
Tf=30;//Teeth of wheel F
y=-120;//Speed of arm A in clockwise in rpm

//Calculations
x=(-y/4)
Nb=x+y;//Speed of wheel B in rpm
Nf=(-10/3)*x+y;//Speed of wheel F in rpm

//Output
mprintf('Speed of wheel B is %3.0f rpm \n Direction of wheel B is clockwise \n Speed of wheel F is %3.0f rpm \n Direction of wheel F is clockwise',Nb,Nf)








//================================END OF PROGRAM==============================
```

Scilab code Exa 4.10 Speed of wheels

```
//Chapter-4, Illustration 10, Page 141
//Title: Gears and Gear Drivers
//=============================================================

clc
clear

//Input data
Ta=96;//Teeth of wheel A
Tc=48;//Teeth of wheel C
y=-20;//Speed of arm C in rpm in clockwise

//Calculations
x=(y*Ta)/Tc
Tb=(Ta-Tc)/2;//Teeth of wheel B
Nb=(-Tc/Tb)*x+y;//Speed of wheel B in rpm
Nc=x+y;//Speed of wheel C in rpm

//Output
mprintf('Speed of wheel B is %3.0f rpm \n Speed of
   wheel C is %3.0f rpm',Nb,Nc)

//=================================END OF PROGRAM
```

Scilab code Exa 4.11 speed of the arm

```
//Chapter-4, Illustration 11, Page 142
//Title: Gears and Gear Drivers
//
clc
clear
//Input data
Ta=40//        no of teeth on gear A
Td=90//        no of teeth on gear D

//Calculations
Tb=(Td-Ta)/2//        no of teeth on gear B
Tc=Tb//             no of teeth on gear C
//
//x+y=-1
//-40x+90y=45
A=[1 1
   -Ta Td]//Coefficient matrix
B=[-1
   (Td/2)]//Constant matrix
X=inv(A)*B//Variable matrix
//
//x+y=-1
//-40x+90y=0
A1=[1 1
   -Ta Td]//Coefficient matrix
B1=[-1
   0]//Constant matrix
X1=inv(A1)*B1//Variable matrix

```

```
disp(X(2))
printf('speed of the arm = %.3f revolution clockwise
    ',X1(2))
```

Scilab code Exa 4.12 Speed of wheel

```
//Chapter-4, Illustration 12, Page 144
//Title: Gears and Gear Drivers
//
================================================================================

clc
clear

//Input data
Te=30;//Teeth of wheel E
Tb=24;//Teeth of wheel B
Tc=22;//Teeth of wheel C
Td=70;//Teeth of wheel D
Th=15;//Teeth of wheel H
Nv=100;//Speed of shaft V in rpm
Nx=300;//Speed of spindle X in rpm

//Calculations
Nh=Nv;//Speed of wheel H in rpm
Ne=(-Th/Te)*Nv;//Speed of wheel E in rpm
Ta=(Tc+Td-Tb);//Teeth of wheel A
//x+y=-50
//y=300
x=(Ne-Nx)
Nz=(187/210)*x+Nx;//;//Speed of wheel Z in rpm

//Output
mprintf('Speed of wheel Z is %3.3f rpm \n Direction
    of wheel Z is opposite to that of X',Nz)
```

Scilab code Exa 4.13 Speed of driven shaft

```
//Chapter-4, Illustration 13, Page 145
//Title: Gears and Gear Drivers
//=============================================================================
clc
clear

//Input data
Tp=20;//Teeth of wheel P
Tq=30;//Teeth of wheel Q
Tr=10;//Teeth of wheel R
Nx=50;//Speed of shaft X in rpm
Na=100;//Speed of arm A in rpm

//Calculations
//x+y=-50
//y=100
x=(-Nx-Na)
y=(-2*x+Na);//Speed of Y in rpm

//Output
mprintf('Speed of driven shaft Y is %3.0f rpm \n
   Direction of driven shaft Y is anti-clockwise',y)
```

Scilab code Exa 4.14 pitch circle diameter

```
//Chapter-4, Illustration 14, Page 146
//Title: Gears and Gear Drivers
```

```
//
clc
clear

//Input data
d=216;//Ring diameter in mm
m=4;//Module in mm

//Calculations
Td=(d/m);//Teeth of wheel D
Tb=Td/4;//Teeth of wheel B
Tb1=ceil(Tb);//Teeth of wheel B
Td1=4*Tb1;//Teeth of wheel D
Tc1=(Td1-Tb1)/2;//Teeth of wheel C
d1=m*Td1;//Pitch circle diameter in mm

//Output
mprintf('Teeth of wheel B is %3.0f \n Teeth of wheel
    C is %3.0f \n Teeth of wheel D is %3.0f \n Exact
    pitch circle diameter is %3.0f mm',Tb1,Tc1,Td1,
    d1)
```

Scilab code Exa 4.15 Revolution of gears

```
//Chapter-4, Illustration 15, Page 147
//Title: Gears and Gear Drivers
//
clc
clear

//Input data
```

```
Ta=100//        no of teeth on gear A
Tc=101//        no of teeth on gear C
Td=99//         no of teeth on gear D
Tp=20//         no of teeth on planet gear
y=1//           from table 4.9(arm B makes one
   revolution)
x=-y//          as gear is fixed

//Calculations
Nc=(Ta*x)/Tc+y//            Revolution of gear C
Nd=(Ta*x)/Td+y//            Revolution of gear D

//Output
printf('Revolution of gear C = %f\n Revolution of
   gear D = %f',Nc,Nd)
```

Scilab code Exa 4.16 speed of road wheel

```
//Chapter-4, Illustration 16, Page 148
//Title: Gears and Gear Drivers
//
   ==========================================================

clc
clear

//Input data
Ta=12//        no of teeth on gear A
Tb=60//        no of teeth on gear B
N=1000//       speed of propeller shaft in rpm
Nc=210//       speed of gear C in rpm

//Calculations
Nb=(Ta*N)/Tb//      speed of gear B in rpm
x=(Nb-Nc)
```

```
Nd=Nb+x//          speed of road wheel driven by D

//Output
printf('speed of road wheel driven by D= %d rpm',Nd)
```

Scilab code Exa 4.17 ratio of torques

```
//Chapter-4, Illustration 17, Page 148
//Title: Gears and Gear Drivers
//=============================================================================
clc
clear
//Input data
Ta=20//   no of teeth on pinion A
Tb=25//   no of teeth on wheel B
Tc=50//   no of teeth on gear C
Td=60//   no of teeth on gear D
Te=60//  no of teeth on gear E
Na=200//   SPEED of the gear A
Nd=100//   speed of the gear D

//calculations
//(i)
//(5/6)x+y=0
//(5/4)x+y=200
A1=[(Tc/Td) 1
    (Tb/Ta) 1]//Coefficient matrix
B1=[0
    Na]//Constant matrix
X1=inv(A1)*B1//Variable matrix
Ne1=X1(2)-(Tc/Td)*X1(1)//
T1=(-Ne1/Na)//      ratio of torques when D is fixed
//(ii)
```

```
//(5/4)x+y=200
//(5/6)x+y=100
A2=[(Tc/Td) 1
    (Tb/Ta) 1]//Coefficient matrix
B2=[Nd
    Na]//Constant matrix
X2=inv(A2)*B2//Variable matrix
Ne2=X2(2)-(Tc/Td)*X2(1)
T2=(-Ne2/Na)//      ratio of torques when D ratates
   at 100 rpm

//Output
printf('speed of E= %.2f rpm in clockwise direction\
   n speed of E in 2nd case(when D rotates at 100
   rpm)= %d rpm in clockwise direction\n ratio of
   torques when D is fixed= %d \n ratio of torques
   when D ratates at 100 rpm= %d',Ne1,Ne2,T1,T2)
```

Chapter 5

Inertia Force Analysis in Machines

Scilab code Exa 5.1 Maximum velocity of the piston

```
//CHAPTER 5 ILLUSRTATION 1 PAGE NO 160
//TITLE:Inertia Force Analysis in Machines
clc
clear
pi=3.141
r=.3//          radius of crank in m
l=1//           length of connecting rod in m
N=200//         speed of the engine in rpm
n=l/r
//====================
w=2*pi*N/60//               angular speed in rad/s
teeta=acosd((-n+((n^2)+4*2*1)^.5)/(2*2))//
   angle of inclination of crank in degrees
Vp=w*r*(sind(teeta)+(sind(2*teeta))/n)//
   maximum velocity of the piston in m/s
printf('Maximum velocity of the piston = %.3f m/s',
   Vp)
```

Scilab code Exa 5.2 position of crank from inner dead centre position for zero acceleration of piston

```
//CHAPTER 5 ILLUSRTATION 2 PAGE NO 161
//TITLE:Inertia Force Analysis in Machines
clc
clear
PI=3.141
r=.3//                length of crank in metres
l=1.5//               length of connecting rod in metres
N=180//               speed of rotation in rpm
teeta=40//            angle of inclination of crank in degrees
//==============================================================
n=l/r
w=2*PI*N/60//         angular speed in rad/s
Vp=w*r*(sind(teeta)+sind(2*teeta)/(2*n))//                 velocity of piston in m/s
fp=w^2*r*(cosd(teeta)+cosd(2*teeta)/(2*n))//               acceleration of piston in m/s^2
costeeta1=(-n+(n^2+4*2*1)^.5)/(2*2)
teeta1=acosd(costeeta1)//    position of crank from inner dead centre position for zero acceleration of piston
//==============================================================
printf('Velocity of Piston = %.3f m/s\n Acceleration of piston = %.3f m/s^2\n position of crank from inner dead centre position for zero acceleration of piston= %.3f degrees',Vp,fp,teeta1)
```

Scilab code Exa 5.3 Turning moment on the crank shaft

```
//CHAPTER 5 ILLUSRTATION 3 PAGE NO 161
//TITLE:Inertia Force Analysis in Machines
clc
clear
pi=3.141
D=.3//           Diameter of steam engine in m
L=.5//           length of stroke in m
r=L/2
mR=100//         equivalent of mass of reciprocating parts in kg
N=200//          speed of engine in rpm
teeta=45//        angle of inclination of crank in degrees
p1=1*10^6//         gas pressure in N/m^2
p2=35*10^3//        back pressure in N/m^2
n=4//               ratio of crank radius to the length of stroke
//====================================================
w=2*pi*N/60//              angular speed in rad/s
Fl=pi/4*D^2*(p1-p2)//      Net load on piston in N
Fi=mR*w^2*r*(cosd(teeta)+cosd(2*teeta)/(2*n))// inertia force due to reciprocating parts
Fp=Fl-Fi//                 Piston effort
T=Fp*r*(sind(teeta)+(sind(2*teeta))/(2*(n^2-(sind(teeta))^2)^.5))
printf('Piston effort = %.3f N\n Turning moment on the crank shaft = %.3f N-m',Fp,T)
```

Scilab code Exa 5.4 net force on piston

```
//CHAPTER 5 ILLUSRTATION 4 PAGE NO 162
//TITLE:Inertia Force Analysis in Machines
clc
clear
pi=3.141
```

```
D=.10//              Diameter of petrol engine in m
L=.12//              Stroke length in m
l=.25//              length of connecting in m
r=L/2
mR=1.2//            mass of piston in kg
N=1800//             speed in rpm
teeta=25//               angle of inclination of crank in degrees
p=680*10^3//         gas pressure in N/m^2
n=l/r
g=9.81//             acceleration due to gravity
//==========================================
w=2*pi*N/60//                        angular speed in rpm
Fl=pi/4*D^2*p//            force due to gas pressure in N
Fi=mR*w^2*r*(cosd(teeta)+cosd(2*teeta)/(n))// inertia force due to reciprocating parts in N
Fp=Fl-Fi+mR*g//                net force on piston in N
Fq=n*Fp/((n^2-(sind(teeta))^2)^.5)//       resultant load on gudgeon pin in N
Fn=Fp*sind(teeta)/((n^2-(sind(teeta))^2)^.5)// thrust on cylinder walls in N
fi=Fl+mR*g//           inertia force of the reciprocating parts before the gudgeon pin load is reversed in N
w1=(fi/mR/r/(cosd(teeta)+cosd(2*teeta)/(n)))^.5
N1=60*w1/(2*pi)
printf('Net force on piston = %.3f N\n Resultant load on gudgeon pin = %.3f N\n Thrust on cylinder walls = %.3f N\n speed at which other things remining same,the gudgeon pin load would be reversed in directionm= %.3f rpm',Fp,Fq,Fn,N1)
```

Scilab code Exa 5.5 Net load on the gudgeon pin

```
//CHAPTER 5 ILLUSRTATION 5 PAGE NO 163
//TITLE:Inertia Force Analysis in Machines
//Figure 5.3
clc
clear
pi=3.141
N=1800//          speed of the petrol engine in rpm
r=.06//           radius of crank in m
l=.240//          length of connecting rod in m
D=.1//            diameter of the piston in m
mR=1//           mass of piston in kg
p=.8*10^6//        gas pressure in N/m^2
x=.012//           distance moved by piston in m
//==============================================================
w=2*pi*N/60//                  angular velocity of the engine in rad/s
n=l/r
Fl=pi/4*D^2*p//             load on the piston in N
teeta=32//                  by mearument from the figure 5.3
Fi=mR*w^2*r*(cosd(teeta)+cosd(2*teeta)/(n))// inertia force due to reciprocating parts in N
Fp=Fl-Fi//               net load on the gudgeon pin in N
Fq=n*Fp/((n^2-(sind(teeta))^2)^.5)//       thrust in the connecting rod in N
Fn=Fp*sind(teeta)/((n^2-(sind(teeta))^2)^.5)// reaction between the piston and cylinder in N
w1=(Fl/mR/r/(cosd(teeta)+cosd(2*teeta)/(n)))^.5
N1=60*w1/(2*pi)//
printf('Net load on the gudgeon pin= %.3f N\n Thrust in the connecting rod= %.3f N\n Reaction between the cylinder and piston= %.3f N\n The engine speed at which the above values become zero= %.3f rpm',Fp,Fq,Fn,N1)
```

Scilab code Exa 5.6 Torque exerted on the crank shaft

```
//CHAPTER 5 ILLUSRTATION 6 PAGE NO 165
//TITLE:Inertia Force Analysis in Machines
clc
clear
pi=3.141
D=.25//                 diameter of horizontal steam engine in m
N=180//                 speed of the engine in rpm
d=.05//                 diameter of piston in m
P=36000//                power of the engine in watts
n=3//                    ration of length of connecting rod to the crank radius
p1=5.8*10^5//             pressure on cover end side in N/m^2
p2=0.5*10^5//              pressure on crank end side in N/m^2
teeta=40//                angle of inclination of crank in degrees
m=45//                    mass of flywheel in kg
k=.65//                   radius of gyration in m
//=================================
Fl=(pi/4*D^2*p1)-(pi/4*(D^2-d^2)*p2)//           load on the piston in N
phi=asind(sind(teeta)/n)// angle of inclination of the connecting rod to the line of stroke in degrees
r=1.6*D/2
T=Fl*sind(teeta+phi)/cosd(phi)*r// torque exerted on crank shaft in N-m
Fb=Fl*cosd(teeta+phi)/cosd(phi)// thrust on the crank shaft bearing in N
TR=P*60/(2*pi*N)//
```

```
steady resisting torque in N-m
Ts=T-TR//surplus torque available in N-m
a=Ts/(m*k^2)//acceleration of the flywheel in rad/s^2
printf('Torque exerted on the crank shaft= %.3f N-m\n Thrust on the crank shaft bearing= %.3f N\n Acceleration of the flywheel= %.3f rad/s^2',T,Fb,a)
```

Scilab code Exa 5.7 Effective turning moment on the crank shaft

```
//CHAPTER 5 ILLUSRTATION 7 PAGE NO 166
//TITLE:Inertia Force Analysis in Machines
clc
clear
pi=3.141
D=.25//                diameter of vertical cylinder of steam engine in m
L=.45//                stroke length in m
r=L/2
n=4
N=360//                 speed of the engine in rpm
teeta=45//              angle of inclination of crank in degrees
p=1050000//                 net pressure in N/m^2
mR=180//                  mass of reciprocating parts in kg
g=9.81//                  acceleration due to gravity
//==========================
Fl=p*pi*D^2/4//                force on piston due to steam pressure in N
w=2*pi*N/60//                  angular speed in rad/s
Fi=mR*w^2*r*(cosd(teeta)+cosd(2*teeta)/(n))//inertia force due to reciprocating parts in N
```

```
Fp=Fl-Fi+mR*g//                    piston effort in N
phi=asind(sind(teeta)/n)//      angle of inclination
    of the connecting rod to the line of stroke in
    degrees
T=Fp*sind(teeta+phi)/cosd(phi)*r//
    torque exerted on crank shaft in N-m
printf('Effective turning moment on the crank shaft=
    %.3f N-m',T)
```

Scilab code Exa 5.8 Effective turning moment on the crank shaft

```
//CHAPTER 5 ILLUSRTATION 8 PAGE NO 166
//TITLE:Inertia Force Analysis in Machines
//figure 5.4
clc
clear
pi=3.141
D=.25//                diameter of vertical cylinder
    of diesel engine in m
L=.40//                stroke length in m
r=L/2
n=4
N=300//                 speed of the engine in rpm
teeta=60//              angle of inclination of crank
    in degrees
mR=200//                 mass of reciprocating parts
    in kg
g=9.81//                 acceleration due to gravity
l=.8//                   length of connecting rod in m
c=14//               compression ratio=v1/v2
p1=.1*10^6//             suction pressure in n/m^2
i=1.35//                 index of the law of expansion
     and compression
//
```

```
Vs=pi/4*D^2*L//              swept volume in m^3
w=2*pi*N/60//                   angular speed in rad/s
Vc=Vs/(c-1)
V3=Vc+Vs/10//               volume at the end of injection of fuel in m^3
p2=p1*c^i//                  final pressure in N/m^2
p3=p2//                      from figure
x=r*((1-cosd(teeta)+(sind(teeta))^2/(2*n)))//           the displacement of the piston when the crank makes an angle 60 degrees with T.D.C
Va=Vc+pi*D^2*x/4
pa=p3*(V3/Va)^i
p=pa-p1//           difference of pressues on 2 sides of piston in N/m^2
Fl=p*pi*D^2/4//      net load on piston in N
Fi=mR*w^2*r*(cosd(teeta)+cosd(2*teeta)/(n))//  inertia force due to reciprocating parts in N
Fp=Fl-Fi+mR*g//                  piston effort in N
phi=asind(sind(teeta)/n)//      angle of inclination of the connecting rod to the line of stroke in degrees
T=Fp*sind(teeta+phi)/cosd(phi)*r//  torque exerted on crank shaft in N-m
printf('Effective turning moment on the crank shaft= %.3f N-m',T)
```

Chapter 6

Turning Moment Diagram and Flywheel

Scilab code Exa 6.1 Kinetic energy of flywheel

```
//CHAPTER 6 ILLUSRTATION 1 PAGE NO 175
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
k=1//          radius of gyration of flywheel in m
m=2000//        mass of the flywheel in kg
T=1000//       torque of the engine in Nm
w1=0//         speedin the begining
t=10//         time duration
//==================================
I=m*k^2//          mass moment of inertia in kg-m^2
a=T/I//            angular acceleration of flywheel in rad/s^2
w2=w1+a*t//        angular speed after time t in rad/s
K=I*w2^2/2//     kinetic energy of flywheel in Nm
//==================================
printf('Angular acceleration of the flywheel= %.3f rad/s^2\n Kinetic energy of flywheel= %.3f N-m',a
```

```
,K)
```

Scilab code Exa 6.2 Mass of the flywheel required

```
//CHAPTER 6 ILLUSRTATION 2 PAGE NO 176
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
pi=3.141
N1=225//                    maximum speed of flywheel in rpm
k=.5//                      radius of gyration of flywheel in m
n=720//                     no of holes punched per hour
E1=15000//                  energy required by flywheel in Nm
N2=200//                    mimimum speedof flywheel in rpm
t=2//                       time taking for punching a hole
//==============================
P=E1*n/3600//                    power required by motor per sec in watts
E2=P*t//                         energy supplied by motor to punch a hole in N-m
E=E1-E2//                        maximum fluctuation of energy in N-m
N=(N1+N2)/2//                    mean speed of the flywheel in rpm
m=E/(pi^2/900*k^2*N*(N1-N2))
printf('Power of the motor= %.3f watts\n Mass of the flywheel required= %.3f kg',P,m)
```

Scilab code Exa 6.3 Mass of the flywheel required

```
//CHAPTER 6 ILLUSRTATION 3 PAGE NO 176
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
pi=3.141
d=38//                diameter of hole in cm
t=32//                thickness of hole in cm
e1=7//                  energy required to punch one square mm
V=25//                  mean speed of the flywheel in m/s
S=100//                  stroke of the punch in cm
T=10//                  time required to punch a hole in s
Cs=.03//                  coefficient of fluctuation of speed
//==================================
A=pi*d*t//                  sheared area in mm^2
E1=e1*A//                   energy required to punch entire area in Nm
P=E1/T//                    power of motor required in watts
T1=T/(2*S)*t//              time required to punch a hole in 32 mm thick plate
E2=P*T1//                   energy supplied by motor in T1 seconds
E=E1-E2//                   maximum fluctuation of energy in Nm
m=E/(V^2*Cs)//              mass of the flywheel required
printf('Mass of the flywheel required= %.0f kg',m)
```

Scilab code Exa 6.4 Mass of the flywheel

```
//CHAPTER 6 ILLUSRTATION 4 PAGE NO 177
//TITLE:Turning Moment Diagram and Flywheel
//figure 6.4
clc
clear
//==============================================
pi=3.141
N=480//                speed of the engine in rpm
k=.6//               radius of gyration in m
Cs=.03//              coefficient of fluctuaion of speed
Ts=6000//             turning moment scale in Nm per one cm
C=30//                crank angle scale in degrees per cm
a=[0.5,-1.22,.9,-1.38,.83,-.7,1.07]//        areas between the output torque and mean resistance line in sq.cm
//========================================================
w=2*pi*N/60//               angular speed in rad/s
A=Ts*C*pi/180//               1 cm^2 of turning moment diagram in Nm
E1=a(1)//                   max energy at B refer figure
E2=a(1)+a(2)+a(3)+a(4)
E=(E1-E2)*A//               fluctuation of energy in Nm
m=E/(k^2*w^2*Cs)//           mass of the flywheel in kg
printf('Mass of the flywheel= %.3f kg',m)
```

Scilab code Exa 6.5 Mass of the flywheel

```
//CHAPTER 6 ILLUSRTATION 5 PAGE NO 178
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
```

```
//==================
pi=3.141
P=500*10^3//          power of the motor in N
k=.6//               radius of gyration in m
Cs=.03//             coefficient of fluctuation of spped
OA=750//              REFER FIGURE
OF=6*pi//             REFER FIGURE
AG=pi// REFER FIGURE
BG=3000-750// REFER FIGURE
GH=2*pi// REFER FIGURE
CH=3000-750// REFER FIGURE
HD=pi// REFER FIGURE
LM=2*pi// REFER FIGURE
T=OA*OF+1/2*AG*BG+BG*GH+1/2*CH*HD//     Torque required for one complete cycle in Nm
Tmean=T/(6*pi)//                        mean torque in Nm
w=P/Tmean//                            angular velocity required in rad/s
BL=3000-1875// refer figure
KL=BL*AG/BG//   From similar trangles
CM=3000-1875// refer figure
MN=CM*HD/CH//from similar triangles
E=1/2*KL*BL+BL*LM+1/2*CM*MN//           Maximum fluctuaion of energy in Nm
m=E*100/(k^2*w^2*Cs)//    mass of flywheel in kg
printf('Mass of the flywheel= %.3f kg',m)
```

Scilab code Exa 6.6 Angular acceleration

```
//CHAPTER 6 ILLUSRTATION 6 PAGE NO 179
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
pi=3.141
```

```
PI=180//in degrees
theta1=0
theta2=PI
m=400//      mass of the flywheel in kg
N=250//      speed in rpm
k=.4//       radius of gyration in m
n=2*250/60000//          no of working strokes per minute
W=1000*pi-150*cosd(2*theta2)-250*sind(2*theta2)-(1000*theta1-150*cosd(2*theta1)-250*sind(2*theta1))//     workdone per stroke in Nm
P=W*n//        power in KW
Tmean=W/pi//          mean torque in Nm
twotheta=atand(500/300)//        angle at which T-Tmean becomes zero
THETA1=twotheta/2
THETA2=(180+twotheta)/2
E=-150*cosd(2*THETA2)-250*sind(2*THETA2)-(-150*cosd(2*THETA1)-250*sind(2*THETA1))//    FLUCTUATION OF ENERGY IN Nm
w=2*pi*N/60//       angular speed in rad/s
Cs1=E*100/(k^2*w^2*m)//    fluctuation range
Cs=Cs1/2//           tatal percentage of fluctuation of speed
Theta=60
T1=300*sind(2*Theta)-500*cosd(2*Theta)//Accelerating torque in Nm(T-Tmean)
alpha=T1/(m*k^2)//angular acceleration in rad/s^2
printf('Power delivered=%.3f kw\nTotal percentage of fluctuation speed= %.3f\nAngular acceleration= %.3f rad/s^2',P,Cs,alpha)
```

Scilab code Exa 6.7 Energy expended in performing each operation

```
//CHAPTER 6 ILLUSRTATION 7 PAGE NO 181
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
pi=3.141
m=200//      mass of the flywheel in kg
k=.5//       radius of gyration in m
N1=360//      upper limit of speed in rpm
N2=240//       lower limit of speed in rpm
//==========
I=m*k^2//         mass moment of inertia in kg m^2
w1=2*pi*N1/60
w2=2*pi*N2/60
E=1/2*I*(w1^2-w2^2)//     fluctuation of energy in Nm
Pmin=E/(4*1000)//        power in kw
Eex=Pmin*12*1000// Energy expended in performing
    each operation in N-m
printf('Mimimum power required= %.3f kw\n Energy
    expended in performing each operation= %.3f N-m',
    Pmin,Eex)
```

Scilab code Exa 6.8 Amount of Torque required

```
//CHAPTER 6 ILLUSRTATION 8 PAGE NO 182
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
pi=3.141
b=8//    width of the strip in cm
t=2//    thickness of the strip in cm
w=1.2*10^3//           work required per square cm
    cut
N1=200//                maximum speed of the
    flywheel in rpm
k=.80//                 radius of gyration in m
```

```
N2=(1-.15)*N1//          minimum speed of the flywheel in rpm
T=3//                    time required to punch a hole
//==============================
A=b*t//            area cut of each stroke in cm^2
W=w*A//            work required to cut a strip in Nm
w1=2*pi*N1/60//          speed before cut in rpm
w2=2*pi*N2/60//          speed after cut in rpm
m=2*W/(k^2*(w1^2-w2^2))//        mass of the flywheel required in kg
a=(w1-w2)/T//            angular acceleration in rad/s^2
Ta=m*k^2*a//               torque required in Nm
printf('Mass of the flywheel= %.3f kg\n Amount of Torque required= %.3f Nm',m,Ta)
```

Scilab code Exa 6.9 Reduction in speed after the pressing is over

```
//CHAPTER 6 ILLUSRTATION 9 PAGE NO 182
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
pi=3.141
P=5*10^3//             power delivered by motor in watts
N1=360//               speed of the flywheel in rpm
I=60//                 mass moment of inertia in kg m^2
E1=7500//              energy required by pressing machine for 1 second in Nm
//===============================
Ehr=P*60*60//        energy sipplied per hour in Nm
n=Ehr/E1
```

```
E=E1-P//              total fluctuation of energy in Nm
w1=2*pi*N1/60//       angular speed before pressing in rpm
w2=((2*pi*N1/60)^2-(2*E/I))^.5//         angular speed after pressing in rpm
N2=w2*60/(2*pi)
R=N1-N2//                  reduction in speed in rpm
printf('No of pressings that can be made per hour= %.0f\n Reduction in speed after the pressing is over= %.2f rpm ',n,R)
```

Scilab code Exa 6.10 miminum mass moment of inertia of flywheel

```


//CHAPTER 6 ILLUSRTATION 10 PAGE NO 183
//TITLE:Turning Moment Diagram and Flywheel
clc
clear
pi=3.141
Cs=.02//      coefficient of fluctuation of speed
N=200//       speed of the engine in rpm
//T2=15000-6000cos              Torque required by the machine in Nm
//T1=15000+8000sin2             Torque supplied by the engine in Nm
//T1-T2=8000sin2 +6000cos        Change in torque
theta1=acosd(0)
theta2=asind(-6000/16000)
theta2=180-theta2
//==================================================
//largest area,representing fluctuation of energy lies between theta1 and theta2
E=6000*sind(theta2)-8000/2*cosd(2*theta2)-(6000*sind(theta1)-8000/2*cosd(2*theta1))//        total
```

```
fluctuation of energy in Nm
Theta=180//     angle with which cycle will be repeated in degrees
Theta1=0
Tmean=1/pi*((15000*pi+(-8000*cosd(2*Theta))/2)-((15000*Theta1+(-8000*cosd(2*Theta1))/2)))//     mean torque of engine in Nm
P=2*pi*N*Tmean/60000//       power of the engine in kw
w=2*pi*N/60//            angular speed of the engine in rad/s
I=E/(w^2*Cs)//           mass moment of inertia of flywheel in kg-m^2
printf('Power of the engine= %.3f kw\n minimum mass moment of inertia of flywheel= %.3f kg-m^2\n E value calculated in the textbook is wrong. Its value is -15,124. In textbook it is given as -1370.28',P,-I)
```

Chapter 7

GOVERNORS

Scilab code Exa 7.1 PERCENTAGE CHANGE IN SPEED

```
//CHAPTER 7 ILLUSRTATION 1 PAGE NO 196
//TITLE:GOVERNORS
clc
clear
//
    ==================================================
//INPUT DATA
L=.4//                          LENGTH OF UPPER ARM IN m
THETA=30//                      INCLINATION TO THE
    VERTICAL IN degrees
K=.02//                         RISED LENGTH IN m
//
    ==================================================
h2=L*cosd(THETA)//              GOVERNOR HEIGHT IN m
N2=(895/h2)^.5//                SPEED AT h2 IN rpm
h1=h2-K//                       LENGTH WHEN IT IS RAISED
    BY 2 cm
N1=(895/h1)^.5//                SPEED AT h1 IN rpm
n=(N1-N2)/N2*100//              PERCENTAGE CHANGE IN
```

```
    SPEED
//
  ==================================================================
printf('PERCENTAGE CHANGE IN SPEED= %.f PERCENTAGE',
    n)
```

Scilab code Exa 7.2 RANGE OF SPEED

```
//CHAPTER 7 ILLUSRTATION 2 PAGE NO 197
//TITLE:GOVERNORS
//FIGURE 7.5(A),7.5(B)
clc
clear
//
  ==================================================================
//INPUT DATA
OA=.3//                               LENGTH OF UPPER ARM
     IN m
m=6//                                 MASS OF EACH BALL
    IN Kg
M=18//                                MASS OF SLEEVE IN
    Kg
r2=.2//                               RADIUS OF ROTATION
    AT BEGINING IN m
r1=.25//                              RADIUS OF ROTATION
    AT MAX SPEED IN m
//
  ==================================================================
h1=(OA^2-r1^2)^.5//                  HIEGHT OF GOVERNOR
    AT MAX SPEED IN m
N1=(895*(m+M)/(h1*m))^.5//           MAX SPEED IN rpm
h2=(OA^2-r2^2)^.5//                  HEIGHT OF GONERNOR
```

```
   AT BEGINING IN m
N2=(895*(m+M)/(h2*m))^.5//      MIN SPEED IN rpm
//
printf('MAX SPEED = %.3f rpm\n MIN SPEED = %.3f rpm\
   n RANGE OF SPEED = %.3f rpm',N1,N2,N1-N2)
```

Scilab code Exa 7.3 RANGE OF SPEED

```
//CHAPTER 7 ILLUSRTATION 3 PAGE NO 197
//TITLE:GOVERNORS
//FIGURE 7.6
clc
clear
//
//INPUT DATA
OA=.25//                                  LENGHT OF
   UPPER ARM IN m
CD=.03//                                  DISTANCE
   BETWEEN LEEVE AND LOWER ARM IN m
m=6//                                     MASS OF
   BALL IN Kg
M=48//                                    MASS OF
   SLEEVE IN Kg
AE=.17//                                   FROM
   FIGURE 7.6
AE1=.12//                                  FROM
   FIGURE 7.6
r1=.2//                                   RADIUS OF
   ROTATION AT MAX SPEED IN m
r2=.15//                                  RADIUS OF
   ROTATION AT MIN SPEED IN m
```

```
//
    ==================================================================
h1=(OA^2-r1^2)^.5//                              HIEGHT OF
    GOVERNOR AT MIN SPEED IN m
TANalpha=r1/h1
TANbeeta=AE/(OA^2-AE^2)^.5
k=TANbeeta/TANalpha
N1=(895*(m+(M*(1+k)/2))/(h1*m))^.5//      MIN SPEED IN
     rpm
h2=(OA^2-r2^2)^.5//                             HIEGHT OF
    GOVERNOR AT MAX SPEED IN m
CE=(OA^2-AE1^2)^.5
TANalpha1=r2/h2
TANbeeta1=(r2-CD)/CE
k=TANbeeta1/TANalpha1
N2=(895*(m+(M*(1+k)/2))/(h2*m))^.5//      MIN SPEED IN
     rpm
//
    ==================================================================
printf('MAX SPEED = %.3f rpm\n MIN SPEED = %.3f rpm\
    n RANGE OF SPEED = %.3f rpm',N1,N2,N1-N2)
```

Scilab code Exa 7.4 GOVERNOR POWER

```
//CHAPTER 7 ILLUSRTATION 4 PAGE NO 199
//TITLE:GOVERNORS
//FIGURE 7.7
clc
clear
//
    ==================================================================
//INPUT DATA
```

```
g=9.81//                        ACCELERATION DUE TO GRAVITY
OA=.20//                        LENGHT OF UPPER ARM IN m
AC=.20//                        LENGTH OF LOWER ARM IN m
CD=.025//                       DISTANCE BETWEEN AXIS AND LOWER ARM IN m
AB=.1//                         RADIUS OF ROTATION OF BALLS IN m
N2=250//                        SPEED OF THE GOVERNOR IN rpm
X=.05//                         SLEEVE LIFT IN m
m=5//                           MASS OF BALL IN Kg
M=20//                          MASS OF SLEEVE IN Kg
//=========================================================================
h2=(OA^2-AB^2)^.5//                     OB DISTANCE IN m IN FIGURE
h21=(AC^2-(AB-CD)^2)^.5//               BD DISTANCE IN m IN FIGURE
TANbeeta=(AB-CD)/h21//                  TAN OF ANGLE OF INCLINATION OF THE LINK TO THE VERTICAL
TANalpha=AB/h2//                        TAN OF ANGLE OF INCLINATION OF THE ARM TO THE VERTICAL
k=TANbeeta/TANalpha
c=X/(2*(h2*(1+k)-X))//                  PERCENTAGE INCREASE IN SPEED
n=c*N2//                                INCREASE IN SPEED IN rpm
N1=N2+n//                               SPEED AFTER LIFT OF SLEEVE
E=c*g*((2*m/(1+k))+M)//                 GOVERNOR EFFORT IN N
P=E*X//                                 GOVERNOR POWER IN N-m

printf('SPEED OF THE GOVERNOR WHEN SLEEVE IS LIFT BY 5 cm = %.3f rpm\n GOVERNOR EFFORT = %.3f N\n
```

```
GOVERNOR POWER = %.3 f N-m',N1,E,P)
```

Scilab code Exa 7.5 RANGE OF SPEED OF GOVERNOR

```
//CHAPTER 7 ILLUSRTATION 5 PAGE NO 200
//TITLE:GOVERNORS
//FIGURE 7.8
clc
clear
//===========================================================================
//INPUT DATA
g=9.81//                    ACCELERATION DUE TO GRAVITY
OA=.30//                   LENGHT OF UPPER ARM IN m
AC=.30//                   LENGTH OF LOWER ARM IN m
m=10//                      MASS OF BALL IN Kg
M=50//                     MASS OF SLEEVE IN Kg
r=.2//                     RADIUS OF ROTATION IN m
CD=.04//                   DISTANCE BETWEEN AXIS AND LOWER ARM IN m
F=15//                     FRICTIONAL LOAD ACTING IN N
//=======================================================================
h=(OA^2-r^2)^.5//               HIEGTH OF THE GOVERNOR IN m
AE=r-CD//                       AE VALUE IN m
CE=(AC^2-AE^2)^.5//             BD DISTANCE IN m
TANalpha=r/h//                  TAN OF ANGLE OF INCLINATION OF THE ARM TO THE VERTICAL
TANbeeta=AE/CE//                TAN OF ANGLE OF INCLINATION OF THE LINK TO THE VERTICAL
```

```
k=TANbeeta/TANalpha
N=((895/h)*(m+(M*(1+k)/2))/m)^.5//         EQULIBRIUM SPEED IN rpm
N1=((895/h)*((m*g)+(M*g+F)/2)*(1+k)/(m*g))^.5//             MAX SPEED IN rpm
N2=((895/h)*((m*g)+(M*g-F)/2)*(1+k)/(m*g))^.5//             MIN SPEED IN rpm
R=N1-N2//                                                  RANGE OF SPEED
printf('EQUILIBRIUM SPEED OF GOVERNOR = %.3f rpm\n RANGE OF SPEED OF GOVERNOR= %.3f rpm',N,R)
```

Scilab code Exa 7.6 RANGE OF SPEED OF GOVERNOR

```
//CHAPTER 7 ILLUSRTATION 6 PAGE NO 202
//TITLE:GOVERNORS
//FIGURE 7.9
clc
clear
//===============================================================================
//INPUT DATA
g=9.81//                      ACCELERATION DUE TO GRAVITY
OA=.30//                      LENGHT OF UPPER ARM IN m
AC=.30//                      LENGTH OF LOWER ARM IN m
m=5//                         MASS OF BALL IN Kg
M=25//                        MASS OF SLEEVE IN Kg
X=.05//                       LIFT OF THE SLEEVE
alpha=30//                    ANGLE OF INCLINATION OF THE ARM TO THE VERTICAL
//=================================================
h2=OA*cosd(alpha)//           HEIGHT OF THE GOVERNOR AT LOWEST POSITION OF SLEEVE
```

```
h1=h2-X/2//                          HEIGHT OF THE GOVERNOR AT HEIGHT POSITION OF SLEEVE
F=((h2/h1)*(m*g+M*g)-(m*g+M*g))/(1+h2/h1)// FRICTION AT SLEEVE IN N
N1=((m*g+M*g+F)*895/(h1*m*g))^.5//              MAX SPEEED OF THE GOVVERNOR IN rpm
N2=((m*g+M*g-F)*895/(h2*m*g))^.5//              MIN SPEEED OF THE GOVVERNOR IN rpm
R=N1-N2//                                        RANGE OF SPEED IN rpm

printf('THE VALUE OF FRICTIONAL FORCE= %.3f F\n RANGE OF SPEED OF THE GOVERNOR = %.0f rpm',F,R)
```

Scilab code Exa 7.7 EQUILIBRIUM SPEED CORRESPONDING TO LIFT

```
//CHAPTER 7 ILLUSRTATION 7 PAGE NO 203
//TITLE:GOVERNORS
clc
clear
//==============================================================================

//INPUT DATA
PI=3.147
m=3//                        MASS OF EACH BALL IN Kg
a=.12//                      LENGTH OF VERTICAL ARM OF BELL CRANK LEVER IN m
b=.08//                      LENGTH OF HORIZONTAL ARM OF BELL CRANK LEVER IN m
r2=.12//                     RADIUS OF ROTATION OF THE BALL FOR LOWEST POSITION IN m
N2=320//                      SPEED OF GOVERNOR AT THE BEGINING IN rpm
S=20000//                        STIFFNESS OF THE SPRING IN
```

```
N/m
h=.015//                            SLEEVE LIFT IN m
//==================================================================
Fc2=m*(2*PI*N2/60)^2*r2//                         CENTRIFUGAL FORCE ACTING AT MIN SPEED OF ROTATION IN N
L=2*a*Fc2/b//                                     INITIAL LOAD ON SPRING IN N
r1=a/b*h+r2//                                     MAX RADIUS OF ROTATION IN m
Fc1=(S*(r1-r2)*(b/a)^2/2)+Fc2//                   CENTRIFUGAL FORCE ACTING AT MAX SPEED OF ROTATION IN N
N1=(Fc1/(m*r1)*(60/2/PI)^2)^.5
printf('INITIAL LOAD ON SPRING =%.3f N\n EQUILIBRIUM SPEED CORRESPONDING TO LIFT OF 15 cm =%.0f rpm',L,N1)
```

Scilab code Exa 7.8 STIFFNESS OF THE SPRING

```
//CHAPTER 7 ILLUSRTATION 8 PAGE NO 204
//TITLE:GOVERNORS
clc
clear
//==================================================================================
//INPUT DATA
PI=3.147
m=3//                                       MASS OF BALL IN Kg
r2=.2//                                     INITIAL RADIUS OF ROTATION IN m
a=.11//                          LENGTH OF VERTICAL ARM OF BELL CRANK LEVER IN m
b=.15//                          LENGTH OF HORIZONTAL ARM OF BELL CRANK LEVER IN m
h=.004//                            SLEEVE LIFT IN m
```

```
N2=240//                INITIAL SPEED IN rpm
n=7.5//                    FLUCTUATION OF SPEED IN %
//==========================================
w2=2*PI*N2/60//                    INITIAL ANGULAR SPEED IN rad/s
w1=(100+n)*w2/100//                FINAL ANGULAR SPEED IN rad/s
F=2*a/b*m*w2^2*r2//                INITIAL COMPRESSIVE FORCE IN N
r1=r2+a/b*h//                      MAX RDIUS OF ROTATION IN m
S=2*((m*w1^2*r1)-(m*w2^2*r2))/(r1-r2)*(a/b)^2
printf('INITIAL COMPRESSIVE FPRCE = %.3f N\n STIFFNESS OF THE SPRING = %.3f N/m',F,S/1000)
```

Scilab code Exa 7.9 ALTERATION IN SPEED

```
//CHAPTER 7 ILLUSRTATION 9 PAGE NO 204
//TITLE:GOVERNORS
//FIGURE 7.3(C)
clc
clear
//==============================================================================
//INPUT DATA
g=9.81//                        ACCELERATION DUE TO GRAVITY
PI=3.147
r=.14//                            DISTANCE BETWEEN THE CENTRE OF PIVOT OF BELL CRANK LEVER AND AXIS OF GOVERNOR SPINDLE IN m
r2=.11//                           INITIAL RADIUS OF ROTATION IN m
a=.12//                            LENGTH OF VERTICAL
```

```
ARM OF BELL CRANK LEVER IN m
b=.10//                              LENGTH OF HORIZONTAL ARM OF BELL CRANK LEVER IN m
h=.05//                              SLEEVE LIFT IN m
N2=240//                             INITIAL SPEED IN rpm
F=30//                               FRICTIONAL FORCE ACTING IN N
m=5//                                MASS OF EACH BALL IN Kg
//==========================================================
r1=r2+a/b*h//                        MAX RADIUS OF ROTATION IN m
N1=41*N2/39//                        MAX SPEED OF ROTATION IN rpm
N=(N1+N2)/2//                        MEAN SPEED IN rpm
Fc1=m*(2*PI*N1/60)^2*r1//            CENTRIFUGAL FORCE ACTING AT MAX SPEED OF ROTATION IN N
Fc2=m*(2*PI*N2/60)^2*r2//            CENTRIFUGAL FORCE ACTING AT MIN SPEED OF ROTATION IN N
c1=r1-r//                            FROM FIGURE 7.3(C) IN m
a1=(a^2-c1^2)^.5//                   FROM FIGURE 7.3(C) IN m
b1=(b^2-(h/2)^2)^.5//                FROM FIGURE 7.3(C) IN m
c2=r-r2//                            FROM FIGURE 7.3(C) IN m
a2=a1//                              FROM FIGURE 7.3(C) IN m
b2=b1//                              FROM FIGURE 7.3(C) IN m
S1=2*((Fc1*a1)-(m*g*c1))/b1//        SPRING FORCE EXERTED ON THE SLEEVE AT MAXIMUM SPEED IN NEWTONS
S2=2*((Fc2*a2)-(m*g*c2))/b2//        SPRING FORCE EXERTED ON THE SLEEVE AT MAXIMUM SPEED IN NEWTONS
S=(S1-S2)/h//                        STIFFNESS OF THE SPRING IN N/m
```

```
Is=S2/S//                          INITIAL COMPRESSION OF SPRING IN m
P=S2+(h/2*S)//                     SPRING FORCE OF MID PORTION IN N
n1=N*((P+F)/P)^.5//                SPEED,WHEN THE SLEEVE BEGINS TO MOVE UPWARDS FROM MID POSITION IN rpm
n2=N*((P-F)/P)^.5//                SPEED,WHEN THE SLEEVE BEGINS TO MOVE DOWNWARDS FROM MID POSITION IN rpm
A=n1-n2//                           ALTERATION IN SPEED IN rpm
printf('INTIAL COMPRESSION OF SPRING= %.3f cm\n ALTERATION IN SPEED = %.3f rpm',Is*100,A)
```

Scilab code Exa 7.10 EQUILIBRIUM SPEED OF GOVERNOR

```
//CHAPTER 7 ILLUSRTATION 10 PAGE NO 206
//TITLE:GOVERNORS
//FIGURE 7.10
clc
clear
//
//INPUT DATA
PI=3.147
AE=.25//                    LENGTH OF UPPER ARM IN m
CE=.25//                    LENGTH OF LOWER ARM IN m
EH=.1//                     LENGTH OF EXTENDED ARM IN m
EF=.15//                    RADIUS OF BALL PATH IN m
m=5//                       MASS OF EACH BALL IN Kg
M=40//                      MASS OF EACH BALL IN Kg
//
```

```
h=(AE^2-EF^2)^.5//                HEIGHT OF THE GOVERNOR
    IN m
EM=h
HM=EH+EM//                        FROM FIGURE 7.10
N=((895/h)*(EM/HM)*((m+M)/m))^.5
printf('EQUILIBRIUM SPEED OF GOVERNOR = %.3f rpm',N)
```

Scilab code Exa 7.11 TENSION IN UPPER ARM

```
//CHAPTER 7 ILLUSRTATION 11 PAGE NO 207
//TITLE:GOVERNORS
//FIGURE 7.11
clc
clear
//
=============================================================
//INPUT DATA
PI=3.147
g=9.81//                      ACCELERATION DUE TO
    GRAVITY IN N/mm^2
AE=.25//                      LENGTH OF UPPER ARM IN m
CE=.25//                      LENGTH OF LOWER ARM IN m
ER=.175//                     FROM FIGURE 7.11
AP=.025//                     FROM FIGURE 7.11
FR=AP//                       FROM FIGURE 7.11
CQ=FR//                       FROM FIGURE 7.11
m=3.2//                         MASS OF BALL IN Kg
M=25//                        MASS OF SLEEVE IN Kg
h=.2//                        VERTICAL HEIGHT OF
    GOVERNOR IN m
EM=h//                        FROM FIGURE 7.11
AF=h//                        FROM FIGURE 7.11
```

```
N=160//                         SPEED OF THE GOVERNOR IN rpm
HM=(895*EM*(m+M)/(h*N^2*m))
x=HM-EM//                       LENGTH OF EXTENDED LINK IN m
T1=g*(m+M/2)*AE/AF//        TENSION IN UPPER ARM IN N
printf('LENGTH OF EXTENDED LINK = %.3f m\n TENSION IN UPPER ARM =%.3f N',x,T1)
```

Scilab code Exa 7.12 MAXIMUM SPEED OF ROTATION

```
//CHAPTER 7 ILLUSRTATION 12 PAGE NO 208
//TITLE:GOVERNORS
//FIGURE 7.12,7.13
clc
clear
//
//INPUT DATA
PI=3.147
EF=.20//                      MINIMUM RADIUS OF ROTATION IN m
AE=.30//                      LENGTH OF EACH ARM IN m
A1E1=AE//                     COMPARING FIRUES 7.12&7.13
EC=.30//                      LENGTH OF EACH ARM IN m
E1C1=EC//                     LENGTH OF EACH ARM IN m
ED=.165//                     FROM FIGURE 7.12 IN m
MC=ED//                       FROM FIGURE 7.12
EH=.10//                       FROM FIGURE 7.12 IN m
m=8//                         MASS OF BALL IN Kg
M=60//                        MASS OF SLEEVE IN Kg
DF=.035//                     SLEEVE DISTANCE FROM AXIS IN m
E1F1=.25//                    MAX RADIUS OF ROTATION IN m
```

```
g=9.81
//
alpha=asind(EF/AE)//      ANGLE OF INCLINATION OF THE ARM TO THE VERTICAL IN DEGREES
beeta=asind(ED/EC)//      ANGLE OF INCLINATION OF THE ARM TO THE HORIZONTAL IN DEGREES
k=tand(beeta)/tand(alpha)
h=(AE^2-EF^2)^.5//         HEIGHT OF GOVERNOR IN m
EM=(EC^2-MC^2)^.5//        FROM FIGURE 7.12 IN m
HM=EM+EH
N2=(895*EM*(m+(M/2*(1+k)))/(h*HM*m))^.5//  EQUILIBRIUM SPEED AT MAX RADIUS
HC=(HM^2+MC^2)^.5//                              FROM FIGURE 7.13 IN m
H1C1=HC
gama=atand(MC/HM)
alpha1=asind(E1F1/A1E1)
E1D1=E1F1-DF//                                          FROM FIGURE 7.13 IN m
beeta1=asind(E1D1/E1C1)
gama1=gama-beeta+beeta1
r=H1C1*sind(gama1)+DF//                                 RADIUS OF ROTATION IN m
H1M1=H1C1*cosd(gama1)
I1C1=E1C1*cosd(beeta1)*(tand(alpha1)+tand(beeta1))// FROM FIGURE IN m
M1C1=H1C1*sind(gama1)
w1=(((m*g*(I1C1-M1C1))+(M*g*I1C1)/2)/(m*r*H1M1))^.5 //   ANGULAR SPEED IN rad/s
N1=w1*60/(2*PI)//                                 //SPEED IN m/s
printf('MINIMUM SPEED OF ROTATION = %.3f rpm\n MAXIMUM SPEED OF ROTATION = %.3f rpm',N2,N1)
```

Chapter 8

balancing of rotating masses

Scilab code Exa 8.1 magnitude of balancing mass

```
//CHAPTER 8 ILLUSRTATION 1 PAGE NO 221
//TITLE:BALANCING OF ROTATING MASSES
pi=3.141
clc
clear
mA=12//        mass of A in kg
mB=10//        mass of B in kg
mC=18//        mass of C in kg
mD=15//        mass of D in kg
rA=40//        radius of A in mm
rB=50//        radius of B in mm
rC=60//        radius of C in mm
rD=30//        radius of D in mm
theta1=0//     angle between A-A in degrees
theta2=60//    angle between A-B in degrees
theta3=130//   angle between A-C in degrees
theta4=270//   angle between A-D in degrees
R=100//  radius at which mass to be determined in mm
//
```

```
Fh=(mA*rA*cosd(theta1)+mB*rB*cosd(theta2)+mC*rC*cosd(theta3)+mD*rD*cosd(theta4))/10//     vertical component value in kg cm
Fv=(mA*rA*sind(theta1)+mB*rB*sind(theta2)+mC*rC*sind(theta3)+mD*rD*sind(theta4))/10//    horizontal component value in kg cm
mb=(Fh^2+Fv^2)^.5/R*10//      unbalanced mass in kg
theta=atand(Fv/Fh)//    position in degrees
THETA=180+theta//        angle with mA
printf('magnitude of unbalaced mass=%.3f kg\n angle with mA= %.3f degrees',mb,THETA)
```

Scilab code Exa 8.2 masses of D and E

```
//CHAPTER 8 ILLUSRTATION 2 PAGE NO 222
//TITLE:BALANCING OF ROTATING MASSES
pi=3.141
clc
clear
mA=5//    mass of A in kg
mB=10//    mass of B in kg
mC=8//      mass of C in kg
rA=10//    radius of A in cm
rB=15//    radius of B in cm
rC=10//     radius of C in cm
rD=10//    radius of D in cm
rE=15//    radius of E in cm
//=====================================
mD=182/rD//     mass of D in kg by mearument
mE=80/rE//      mass of E in kg  by mearument
printf('mass of D= %.3f kg\nmass of E= %.3f kg',mD,mE)
```

Scilab code Exa 8.3 balancing mass and angular position

```
//CHAPTER 8 ILLUSRTATION 3 PAGE NO 223
//TITLE:BALANCING OF ROTATING MASSES
pi=3.141
clc
clear
mA=200//        mass of A in kg
mB=300//        mass of B in kg
mC=400//        mass of C in kg
mD=200//        mass of D in kg
rA=80//        radius of A in mm
rB=70//        radius of B in mm
rC=60//        radius of C in mm
rD=80//        radius of D in mm
rX=100//       radius of X in mm
rY=100//      radius of Y in mm
//==========================
mY=7.3/.04//     mass of Y in kg by mearurement
mX=35/.1//       mass of X in kg by mearurement
thetaX=146//    in degrees by mesurement
printf('mass of X=%.3f kg\n mass of Y=%.3f kg\n
   angle with mA=%.0f degrees',mX,mY,thetaX)
```

Scilab code Exa 8.4 balancing mass and angular position

```
//CHAPTER 8 ILLUSRTATION 4 PAGE NO 225
//TITLE:BALANCING OF ROTATING MASSES
pi=3.141
clc
clear
mB=30//        mass of B in kg
mC=50//        mass of C in kg
mD=40//        mass of D in kg
rA=18//        radius of A in cm
```

```
rB=24//        radius of B in cm
rC=12//        radius of C in cm
rD=15//        radius of D in cm
//==================================
mA=3.6/.18//          mass of A by measurement in kg
theta=124//           angle with mass B in degrees by
    measurement in degrees
y=3.6/(.18*20)//      position of A from B
printf('mass of A=%i kg\n angle with mass B=%i
   degrees\n position of A from B=%i m towards right
    of plane B',mA,theta,y)
```

Scilab code Exa 8.5 balancing mass and angular position

```
//CHAPTER 8 ILLUSRTATION 5 PAGE NO 226
//TITLE:BALANCING OF ROTATING MASSES
pi=3.141
clc
clear
mB=10//        mass of B in kg
mC=5//        mass of C in kg
mD=4//        mass of D in kg
rA=10//        radius of A in cm
rB=12.5//        radius of B in cm
rC=20//        radius of C in cm
rD=15//        radius of D in cm
//============================================
mA=7//       mass of A in kg by mesurement
BC=118//      angle between B and C in degrees by
   mesurement
BA=203.5//    angle between B and A in degrees by
   mesurement
BD=260//      angle between B and D in degrees by
   mesurement
printf('Mass of A=%i kg\n angle between B and C=%i
```

```
degrees\nangle between B and A= %.1f degrees\n
angle between B and D= %i degrees',mA,BC,BA,BD)
```

Scilab code Exa 8.6 mass of D

```
//CHAPTER 8 ILLUSRTATION 6 PAGE NO 228
//TITLE:BALANCING OF ROTATING MASSES
pi=3.141
clc
clear
mB=36//        mass of B in kg
mC=25//        mass of C in kg
rA=20//        radius of A in cm
rB=15//        radius of B in cm
rC=15//        radius of C in cm
rD=20//        radius of D in cm
//==========================================
mA=3.9/.2//        mass of A in kg by measurement
mD=16.5//        mass of D in kg by measurement
theta=252//        angular position of D from B by
    measurement in degrees
printf('Mass of A= %.1f kg\n Mass od D= %.1f kg\n
    Angular position of D from B= %i degrees',mA,mD,
    theta)
```

Scilab code Exa 8.7 load on each bearing

```
//CHAPTER 8 ILLUSRTATION 7 PAGE NO 229
//TITLE:BALANCING OF ROTATING MASSES

clc
clear
pi=3.141
```

```
mA=48//      mass of A in kg
mB=56//        mass of B in kg
mC=20//        mass of C in kg
rA=1.5//        radius of A in cm
rB=1.5//        radius of B in cm
rC=1.25//        radius of C in cm
N=300//   speed in rpm
d=1.8//   distance between bearing in cm
//==========================================
w=2*pi*N/60//         angular speed in rad/s
BA=164//     angle between pulleys B&A in degrees by measurement
BC=129//     angle between pulleys B&C in degrees by measurement
AC=67//      angle between pulleys A&C in degrees by measurement
C=.88*w^2//     out of balance couple in N
L=C/d//    load on each bearing in N
printf('angle between pulleys B&A=%i degrees\n angle between pulleys B&C= %i degrees\n angle between pulleys A&C= %i degrees\n out of balance couple= %.3f N\n load on each bearing= %.3f N',BA,BC,AC,C,L)
```

Chapter 9

cams and followers

Scilab code Exa 9.2 maximum velocity and acceleration

```
//CHAPTER 9 ILLUSRTATION 2 PAGE NO 247
//TITLE:CAMS AND FOLLOWERS
clc
clear
pi=3.141
s=4//          follower movement in cm
theta=60//     cam rotation in degrees
THETA=60*pi/180//    cam rotation in rad
thetaD=45//     after outstroke in degrees
thetaR=90//....angle with which it reaches its
   original position in degrees
THETAR=90*pi/180//    angle with which it reaches its
    original position in rad
THETAd=360-theta-thetaD-thetaR//       angle after
   return stroke in degrees
N=300//    speed in rpm
w=2*pi*N/60//    speed in rad/s
Vo=pi*w*s/2/THETA//    Maximum velocity of follower
   during outstroke in cm/s
Vr=pi*w*s/2/THETAR// Maximum velocity of follower
   during return stroke in cm/s
```

```
Fo=pi^2*w^2*s/2/THETA^2/100//Maximum acceleration of follower during outstroke in m/s^2
Fr=pi^2*w^2*s/2/THETAR^2/100//Maximum acceleration of follower during return stroke in m/s^2
printf('Maximum acceleration of follower during outstroke =%.3f m/s^2\nMaximum acceleration of follower during return stroke= %.3f m/s^2',Fo,Fr)
```

Scilab code Exa 9.3 maximum velocity and acceleration

```
//CHAPTER 9 ILLUSRTATION 3 PAGE NO 249
//TITLE:CAMS AND FOLLOWERS
clc
clear
pi=3.141
s=5//          follower movement in cm
theta=120//    cam rotation in degrees
THETA=theta*pi/180//   cam rotation in rad
thetaD=30//    after outstroke in degrees
thetaR=60//....angle with which it reaches its original position in degrees
THETAR=60*pi/180//   angle with which it reaches its original position in rad
THETAd=360-theta-thetaD-thetaR//      angle after return stroke in degrees
N=100//   speed in rpm
w=2*pi*N/60//   speed in rad/s
Vo=pi*w*s/2/THETA//   Maximum velocity of follower during outstroke in cm/s
Vr=pi*w*s/2/THETAR// Maximum velocity of follower during return stroke in cm/s
Fo=pi^2*w^2*s/2/THETA^2/100//Maximum acceleration of follower during outstroke in m/s^2
Fr=pi^2*w^2*s/2/THETAR^2/100//Maximum acceleration of follower during return stroke in m/s^2
```

```
printf('Maximum acceleration of follower during outstroke =%.3f m/s^2\nMaximum acceleration of follower during return stroke= %.3f m/s^2',Fo,Fr)
```

Scilab code Exa 9.5 maximum velocity and acceleration

```
//CHAPTER 9 ILLUSRTATION 5 PAGE NO 252
//TITLE:CAMS AND FOLLOWERS
clc
clear
pi=3.141
N=1000//    speed of cam in rpm
w=2*pi*N/60//  angular speed in rad/s
s=2.5//   stroke of the follower in cm
THETA=120*pi/180//  ANGULAR DISPLACEMENT OF CAM DURING OUTSTROKE IN RAD
THETAR=90*pi/180//ANGULAR DISPLACEMENT OF CAM DURING DWELL IN RAD
Vo=2*w*s/THETA//   Maximum velocity of follower during outstroke in cm/s
Vr=2*w*s/THETAR//Maximum velocity of follower during return stroke in cm/s
Fo=4*w^2*s/THETA^2//Maximum acceleration of follower during outstroke in m/s^2
Fr=4*w^2*s/THETAR^2//Maximum acceleration of follower during return stroke in m/s^2
printf('Maximum acceleration of follower during outstroke =%.3f m/s^2\nMaximum acceleration of follower during return stroke= %.3f m/s^2',Fo,Fr)
```

Chapter 10

Brakes and Dynamometers

Scilab code Exa 10.1 Torque transmitted by the block brake

```
//CHAPTER 10 ILLUSRTATION 1 PAGE NO 268
//TITLE:Brakes and Dynamometers
clc
clear
//==============================================================================
//INPUT DATA
d=0.32;//Diameter of the drum in m
qq=90;//Angle of contact in degree
P=820;//Force applied in N
U=0.35;//Coefficient of friction


U1=((4*U*sind(qq/2))/((qq*(3.14/180))+sind(qq)));//Equivalent coefficient of friction
F=((P*0.66)/((0.3/U1)-0.06));//Force value in N taking moments
TB=(F*(d/2));//Torque transmitted in N.m

printf('Torque transmitted by the block brake is %3
```

```
.4 f N.m',TB)
```

Scilab code Exa 10.2 DISTANCE TRAVELLED BY CYCLE

```
//CHAPTER 10 ILLUSRTATION 2 PAGE NO 269
//TITLE:Brakes and Dynamometers
clc
clear
//
===========================================================
//INPUT DATA
m=120;//Mass of rider in kg
v=16.2;//Speed of rider in km/hr
d=0.9;//Diameter of the wheel in m
P=120;//Pressure applied on the brake in N
U=0.06;//Coefficient of friction

F=(U*P);//Frictional force in N
KE=((m*(v*(5/18))^2)/2);//Kinematic Energy in N.m
S=(KE/F);//Distance travelled by the bicycle before
    it comes to rest in m
N=(S/(d*3.14));//Required number of revolutions

printf('The bicycle travels a distance of %3.2f m
    and makes %3.2f turns before it comes to rest',S,
    N)
```

Scilab code Exa 10.3 Maximum torque absorbed

```
//CHAPTER 10 ILLUSRTATION 3 PAGE NO 270
//TITLE:Brakes and Dynamometers
clc
```

```
clear
//
```

```
//INPUT DATA
S=3500;//Force on each arm in N
d=0.36;//Diamter of the wheel in m
U=0.4;//Coefficient of friction
qq=100;//Contact angle in degree

qqr=(qq*(3.14/180));//Contact angle in radians
UU=((4*U*sind(qq/2))/(qqr+(sind(qq))));//Equivalent
    coefficient of friction
F1=(S*0.45)/((0.2/UU)+((d/2)-0.04));//Force on
    fulcrum in N
F2=(S*0.45)/((0.2/UU)-((d/2)-0.04));//Force on
    fulcrum in N
TB=(F1+F2)*(d/2);//Maximum torque absorbed in N.m

printf('Maximum torque absorbed is %3.2f N.m',TB)
```

Scilab code Exa 10.4 The maximum braking torque on the drum

```
//CHAPTER 10 ILLUSRTATION 4 PAGE NO 271
//TITLE:Brakes and Dynamometers
clc
clear
//
```

```
//INPUT DATA
a=0.5;//Length of lever in m
d=0.5;//Diameter of brake drum in m
q=(5/8)*(2*3.14);//Angle made in radians
b=0.1;//Distance between pin and fulcrum in m
```

```
P=2000;//Effort applied in N
U=0.25;//Coefficient of friction

T=exp(U*q);//Ratios of tension
T2=((P*a)/b);//Tension in N
T1=(T*T2);//Tension in N
TB=((T1-T2)*(d/2))/1000;//Maximum braking torque in kNm

printf('The maximum braking torque on the drum is %3.3f kNm',TB)
```

Scilab code Exa 10.5 Tensions in the side

```
//CHAPTER 10 ILLUSRTATION 5 PAGE NO 271
//TITLE:Brakes and Dynamometers
clc
clear
//==============================================================================================
//INPUT DATA
q=220;//Angle of contact in degree
T=340;//Torque in Nm
d=0.32;//Diameter of drum in m
U=0.3;//Coefficient of friction

Td=(T/(d/2));//Difference in tensions in N
Tr=exp(U*(q*(3.14/180)));//Ratio of tensions
T2=(Td/(Tr-1));//Tension in N
T1=(Tr*T2);//Tension in N
P=((T2*(d/2))-(T1*0.04))/0.5;//Force applied in N
b=(T1/T2)*4;//Value of b in cm when the brake is self-locking

```

```
printf('The value of b is %3.2f cm when the brake is
    self-locking \n Tensions in the sides are %3.3f
   N and %3.3f N',b,T1,T2)
```

Scilab code Exa 10.6 Torque required

```
//CHAPTER 10 ILLUSRTATION 6 PAGE NO 272
//TITLE:Brakes and Dynamometers
clc
clear
//
//INPUT DATA
d=0.5;//Drum diamter in m
U=0.3;//Coefficient of friction
q=250;//Angle of contact in degree
P=750;//Force in N
a=0.1;//Band width in m
b=0.8;//Distance in m
ft=(70*10^6);//Tensile stress in Pa
f=(60*10^6);//Stress in Pa
b1=0.1;//Distance in m

T=exp(U*(q*(3.14/180)));//Tensions ratio
T2=(P*b*10)/(T+1);//Tension in N
T1=(T*T2);//Tension in N
TB=(T1-T2)*(d/2);//Torque in N.m
t=(max(T1,T2)/(ft*a))*1000;//Thickness in mm
M=(P*b);//bending moment at fulcrum in Nm
X=(M/((1/6)*f));//Value of th^2
//t varies from 10mm to 15 mm. Taking t=15mm,
h=sqrt(X/(0.015))*1000;//Section of the lever in m

printf('Torque required is %3.2f N.m \nThickness
```

```
necessary to limit the tensile stress to 70 MPa
is %3.3f mm \n Section of the lever taking stress
 to 60 MPa is %3.1f mm',TB,t,h)
```

Scilab code Exa 10.7 Power TO BD ratio

```
//CHAPTER 10 ILLUSRTATION 7 PAGE NO 273
//TITLE:Brakes and Dynamometers
clc
clear
//
//INPUT DATA
P1=30;//Power in kW
N=1250;//Speed in r.p.m
P=60;//Applied force in N
d=0.8;//Drum diameter in m
q=310;//Contact angle in degree
a=0.03;//Length of a in m
b=0.12;//Length of b in m
U=0.2;//Coefficient of friction
B=10;//Band width in cm
D=80;//Diameter in cm

T=(P1*60000)/(2*3.14*N);//Torque in N.m
Td=(T/(d/2));//Tension difference in N
Tr=exp(U*(q*(3.14/180)));//Tensions ratio
T2=(Td/(Tr-1));//Tension in N
T1=(Tr*T2);//Tension in N
x=((T2*b)-(T1*a))/P;//Distance in m;
X=(P1/(B*D));//Ratio

printf('Value of x is %3.4f m \n Value of (Power/bD)
    ratio is %3.4f',x,X)
```

Scilab code Exa 10.8 Time required to bring the shaft to the rest from its running condition

```
//CHAPTER 10 ILLUSRTATION 8 PAGE NO 274
//TITLE:Brakes and Dynamometers
clc
clear
//
===============================================================================================================
//INPUT DATA
m=80;//Mass of flywheel in kg
k=0.5;//Radius of gyration in m
N=250;//Speed in r.p.m
d=0.32;//Diamter of the drum in m
b=0.05;//Distance of pin in m
q=260;//Angle of contact in degree
U=0.23;//Coefficient of friction
P=20;//Force in N
a=0.35;//Distance at which force is applied in m

Tr=exp(U*q*(3.14/180));//Tensions ratio
T2=(P*a)/b;//Tension in N
T1=(Tr*T2);//Tension in N
TB=(T1-T2)*(d/2);//Torque in N.m
KE=((1/2)*(m*k^2)*((2*3.14*N)/60)^2);//Kinematic
   energy of the rotating drum in Nm
N1=(KE/(TB*2*3.14));//Speed in rpm
aa=((2*3.14*N)/60)^2/(4*3.14*N1);//Angular
   acceleration in rad/s^2
t=((2*3.14*N)/60)/aa;//Time in seconds

printf('Time required to bring the shaft to the rest
    from its running condition is %3.1f seconds',t)
```

Scilab code Exa 10.9 Minimum force required

```
//CHAPTER 10 ILLUSRTATION 9 PAGE NO 275
//TITLE:Brakes and Dynamometers
clc
clear
//
//INPUT DATA
n=12;//Number of blocks
q=15;//Angle subtended in degree
P=185;//Power in kW
N=300;//Speed in r.p.m
U=0.25;//Coefficient of friction
d=1.25;//Diamter in m
b1=0.04;//Distance in m
b2=0.14;//Distance in m
a=1;//Diatance in m
m=2400;//Mass of rotor in kg
k=0.5;//Radius of gyration in m

Td=(P*60000)/(2*3.14*N*(d/2));//Tension difference in N
T=Td*(d/2);//Torque in Nm
Tr=((1+(U*tand(q/2)))/(1-(U*tand(q/2))))^n;//Tension ratio
To=(Td/(Tr-1));//Tension in N
Tn=(Tr*To);//Tension in N
P=((To*b2)-(Tn*b1))/a;//Force in N
aa=(T/(m*k^2));//Angular acceleration in rad/s^2
t=((2*3.14*N)/60)/aa;//Time in seconds

printf('Minimum force required is %3.0f N \nTime
```

```
taken to bring to rest is %3.1f seconds',P,t)
```

Scilab code Exa 10.10 Maximum braking torque

```
//CHAPTER 10 ILLUSRTATION 10 PAGE NO 275
//TITLE:Brakes and Dynamometers
clc
clear
//
//INPUT DATA
n=12;// Number of blocks
q=16;//Angle subtended in degrees
d=0.9;//Effective diameter in m
m=2000;//Mass in kg
k=0.5;//Radius of gyration in m
b1=0.7;//Distance in m
b2=0.03;//Distance in m
a=0.1;//Distance in m
P=180;//Force in N
N=360;//Speed in r.p.m
U=0.25;//Coefficient of friction

Tr=((1+(U*tand(q/2)))/(1-(U*tand(q/2))))^n;// Tensions ratio
T2=(P*b1)/(a-(b2*Tr));//Tension in N
T1=(Tr*T2);//Tension in N
TB=(T1-T2)*(d/2);//Torque in N.m
aa=(TB/(m*k^2));//Angular acceleration in rad/s^2
t=((2*3.14*N)/60)/aa;//Time in seconds

printf('(i) Maximum braking torque is %3.4f Nm \n(ii) Angular retardation of the drum is %3.4f rad/s^2 \n(iii) Time taken by the system to come to
```

```
rest is %3.1f s',TB,aa,t)
```

Chapter 11

VIBRATIONS

Scilab code Exa 11.1 FREQUENCY OF TRANSVERSE VIBRATION

```
//CHAPTER 11 ILLUSRTATION 1 PAGE NO 290
//TITLE:VIBRATIONS
clc
clear
//
    ============================================================
//INPUT DATA
PI=3.147
D=.1//                              DIAMETER OF SHAFT
   IN m
L=1.10//                             LENGTH OF SHAFT IN
    m
W=450//                             WEIGHT ON THE OTHER
    END OF SHAFT IN NEWTONS
E=200*10^9//                        YOUNGS MODUKUS OF
   SHAFT MATERIAL IN Pascals
//
    ============================================================
A=PI*D^2/4//                        AREA OF SHAFT IN mm
```

```
^2
I=PI*D^4/64//                    MOMENT OF INERTIA
delta=W*L/(A*E)//                STATIC DEFLECTION IN LONGITUDINAL VIBRATION OF SHAFT IN m
Fn=0.4985/(delta)^.5//           FREQUENCY OF LONGITUDINAL VIBRATION IN Hz
delta1=W*L^3/(3*E*I)//           STATIC DEFLECTION IN TRANSVERSE VIBRATION IN m
Fn1=0.4985/(delta1)^.5//         FREQUENCY OF TRANSVERSE VIBRATION  IN Hz
//==============================================================================
//OUTPUT
printf('FREQUENCY OF LONGITUDINAL VIBRATION =%.3f Hz\n FREQUENCY OF TRANSVERSE VIBRATION =%.3f Hz',Fn,Fn1)
```

Scilab code Exa 11.2 NATURAL FREQUENCY OF TRANSVERSE VIBRATION

```
//CHAPTER 11 ILLUSRTATION 2 PAGE NO 290
//TITLE:VIBRATIONS
//FIGURE 11.10
clc
clear
//==============================================================================
//INPUT DATA
PI=3.147
L=.9//                           LENGTH OF THE SHAFT IN m
m=100//                          MASS OF THE BODY IN Kg
```

```
L2=.3//                                LENGTH WHERE THE WEIGHT IS ACTING IN m
L1=L-L2//                              DISTANCE FROM THE OTHER END
D=.06//                                DIAMETER OF SHAFT IN m
W=9.81*m//                             WEGHT IN NEWTON
E=200*10^9//                            YOUNGS MODUKUS OF SHAFT MATERIAL IN Pascals
//
//CALCULATION
I=PI*D^4/64//                          MOMENT OF INERTIA IN m^4
delta=W*L1^2*L2^2/(3*E*I*L)//   STATIC DEFLECTION
Fn=.4985/(delta)^.5//                  NATURAL FREQUENCY OF TRANSVERSE VIBRATION
//
//OUTPUT
printf('NATURAL FREQUENCY OF TRANSVERSE VIBRATION=%.3f Hz',Fn)
```

Scilab code Exa 11.3 FREQUENCY OF TORSIONAL VIBRATION

```
//CHAPTER 11 ILLUSRTATION 3 PAGE NO 291
//TITLE:VIBRATIONS
//FIGURE 11.11
clc
clear
//
```

```
//INPUT DATA
PI=3.147
g=9.81//
    ACCELERATION DUE TO GRAVITY IN N /m^2
D=.050//
    DIAMETER OF SHAFT IN m
m=450//                                                    WEIGHT
    OF FLY WHEEL IN IN Kg
K=.5//                                                     RADIUS
    OF GYRATION IN m
L2=.6//                                                   FROM
    FIGURE IN m
L1=.9//                                                   FROM
    FIGURE IN m
L=L1+L2
E=200*10^9//                              YOUNGS MODUKUS OF
    SHAFT MATERIAL IN Pascals
C=84*10^9//                               MODUKUS OF RIDITY
    OF SHAFT MATERIAL IN Pascals
//
    ==================================================================
A=PI*D^2/4//                                              AREA OF
    SHAFT IN mm^2
I=PI*D^4/64//
m1=m*L2/(L1+L2)//                                         MASS OF
    THE FLYWHEEL CARRIED BY THE LENGTH L1 IN Kg
DELTA=m1*g*L1/(A*E)//
    EXTENSION OF LENGTH L1 IN m
Fn=0.4985/(DELTA)^.5//
    FREQUENCY OF LONGITUDINAL VIBRATION IN Hz
DELTA1=(m*g*L1^3*L2^3)/(3*E*I*L^3)//          STATIC
    DEFLECTION IN TRANSVERSE VIBRATION IN m
Fn1=0.4985/(DELTA1)^.5//
    FREQUENCY OF TRANSVERSE VIBRATION  IN Hz
J=PI*D^4/32//                                             POLAR
    MOMENT OF INERTIA IN m^4
Q1=C*J/L1//
```

```
TORSIONAL STIFFNESS OF SHAFT DUE TO L1 IN N-m
Q2=C*J/L2//
   TORSIONAL STIFFNESS OF SHAFT DUE TO L2 IN N-m
Q=Q1+Q2//
   TORSIONAL STIFFNESS OF SHAFT IN Nm
Fn2=(Q/(m*K^2))^.5/(2*PI)//
   FREQUENCY OF TORSIONAL VIBRATION  IN Hz
//
   ==========================================================================
printf('FREQUENCY OF LONGITUDINAL VIBRATION = %.3f
   Hz\n FREQUENCY OF TRANSVERSE VIBRATION = %.3f  Hz\
   n FREQUENCY OF TORSIONAL VIBRATION = %.3f  Hz',Fn,
   Fn1,Fn2)
```

Scilab code Exa 11.6 FREQUENCY OF TRANSVERSE VIBRATION

```
//CHAPTER 11 ILLUSRTATION 6 PAGE NO 294
//TITLE:VIBRATIONS
//FIGURE 11.14
clc
clear
//
   ==========================================================================
//INPUT DATA
PI=3.147
g=9.81//
   ACCELERATION DUE TO GRAVITY IN N /m^2
D=.06//
   DIAMETER OF SHAFT IN m
L=3//                                                   LENGTH
    OF SHAFT IN m
W1=1500//                                               WEIGHT
    ACTING AT C IN N
```

```
W2=2000//                                    WEIGHT ACTING AT D IN N
W3=1000//                                    WEIGHT ACTING AT E IN N
L1=1//                                       LENGTH FROM A TO C IN m
L2=2//                                       LENGTH FROM A TO D IN m
L3=2.5//                                     LENGTH FROM A TO E IN m
I=PI*D^4/64
E=200*10^9//                        YOUNGS MODUKUS OF SHAFT MATERIAL IN Pascals
//==============================================================================
DELTA1=W1*L1^2*(L-L1)^2/(3*E*I*L)//          STATIC DEFLECTION DUE TO W1
DELTA2=W2*L2^2*(L-L2)^2/(3*E*I*L)//          STATIC DEFLECTION DUE TO W2
DELTA3=W2*L3^2*(L-L3)^2/(3*E*I*L)//          STATIC DEFLECTION DUE TO W2
Fn=.4985/(DELTA1+DELTA2+DELTA3)^.5//  FREQUENCY OF TRANSVERSE VIBRATION  IN Hz
//==============================================================================
printf('FREQUENCY OF TRANSVERSE VIBRATION = %.3f Hz',Fn)
```

Scilab code Exa 11.10 FREQUENCY OF TRANSVERSE VIBRATION

```
//CHAPTER 11 ILLUSRTATION 10 PAGE NO 296
//TITLE:VIBRATIONS
//FIGURE 11.18
```

```
clc
clear
//
//INPUT DATA
PI=3.147
g=9.81//ACCELERATION DUE TO GRAVITY IN N /m^2
E=200*10^9//YOUNGS MODUKUS OF SHAFT MATERIAL IN Pascals
D=.03//DIAMETER OF SHAFT IN m
L=.8//LENGTH OF SHAFT IN m
r=40000//DENSITY OF SHAFT MATERIAL IN Kg/m^3
W=10//WEIGHT ACTING AT CENTRE IN N
//
I=PI*D^4/64//MOMENT OF INERTIA OF SHAFT IN m^4
m=PI*D^2/4*r//MASS PER UNIT LENGTH IN Kg/m
w=m*g
DELTA=W*L^3/(48*E*I)//STATIC DEFLECTION DUE TO W
DELTA1=5*w*L^4/(384*E*I)//STATIC DEFLECTION DUE TO WEIGHT OF SHAFT
Fn=.4985/(DELTA+DELTA1/1.27)^.5
//
printf('FREQUENCY OF TRANSVERSE VIBRATION = %.3f Hz',Fn)
```

Scilab code Exa 11.11 CRITICAL SPEED OF SHAFT

```
//CHAPTER 11 ILLUSRTATION 11 PAGE NO 297
//TITLE:VIBRATIONS
//FIGURE 11.19
clc
clear
//
    ===========================================================================

//INPUT DATA
PI=3.147
g=9.81//
    ACCELERATION DUE TO GRAVITY IN N /m^2
E=210*10^9//                                                    YOUNGS
     MODUKUS OF SHAFT MATERIAL IN Pascals
D=.18//
    DIAMETER OF SHAFT IN m
L=2.5//                                                         LENGTH
     OF SHAFT IN m
M1=25//                                                         MASS
    ACTING AT E IN Kg
M2=50//                                                         MASS
    ACTING AT D IN Kg
M3=20//                                                         MASS
    ACTING AT C IN Kg
W1=M1*g
W2=M2*g
W3=M3*g
L1=.6//                                                         LENGTH
     FROM A TO E IN m
L2=1.5//                                                        LENGTH
     FROM A TO D IN m
L3=2//                                                          LENGTH
```

```
    FROM A TO C IN m
w=1962//                                       SELF WEIGHT OF SHAFT IN N
//====================================================================

I=PI*D^4/64//                                  MOMENT OF INERTIA OF SHAFT IN m^4
DELTA1=W1*L1^2*(L-L1)^2/(3*E*I*L)//            STATIC DEFLECTION DUE TO W1
DELTA2=W2*L2^2*(L-L2)^2/(3*E*I*L)//            STATIC DEFLECTION DUE TO W2
DELTA3=W3*L3^2*(L-L3)^2/(3*E*I*L)//            STATIC DEFLECTION DUE TO W3
DELTA4=5*w*L^4/(384*E*I)//                     STATIC DEFLECTION DUE TO w
Fn=.4985/(DELTA1+DELTA2+DELTA3+DELTA4/1.27)^.5
Nc=Fn*60//                                     CRITICAL SPEED OF SHAFT IN rpm
//====================================================================

printf('CRITICAL SPEED OF SHAFT = %.3f rpm',Nc)
```

Scilab code Exa 11.12 FREQUENCY OF FREE TORSIONAL VIBRATION

```
//CHAPTER 11 ILLUSRTATION 12 PAGE NO 298
//TITLE:VIBRATIONS
//FIGURE 11.20
clc
clear
//====================================================================
```

```
//INPUT DATA
PI=3.147
g=9.81//ACCELERATION DUE TO GRAVITY IN N /m^2
Na=1500//                                    SPEED OF SHAFT A IN rpm
Nb=500//                                     SPEED OF SHAFT B IN rpm
G=Na/Nb//                                    GERA RATIO
L1=.18//LENGTH OF SHAFT 1 IN m
L2=.45//LENGTH OF SHAFT 2 IN m
D1=.045//DIAMETER OF SHAFT 1 IN m
D2=.09//DIAMETER OF SHAFT 2 IN m
C=84*10^9//                     MODUKUS OF RIDITY OF SHAFT MATERIAL IN Pascals
Ib=1400//                       MOMENT OF INERTIA OF PUMP IN Kg-m^2
Ia=400//                        MOMENT OF INERTIA OF MOTOR IN Kg-m^2

//

J=PI*D1^4/32//                               POLAR MOMENT OF INERTIA IN m^4
Ib1=Ib/G^2//                    MASS MOMENT OF INERTIA OF EQUIVALENT ROTOR IN m^2
L3=G^2*L2*(D1/D2)^4//           ADDITIONAL LENGTH OF THE EQUIVALENT SHAFT
L=L1+L3//                        TOTAL LENGTH OF EQUIVALENT SHAFT
La=L*Ib1/(Ia+Ib1)
Fn=(C*J/(La*Ia))^.5/(2*PI)//     FREQUENCY OF FREE
```

```
    TORSIONAL VIBRATION IN Hz
//
    ============================================================
printf('FREQUENCY OF FREE TORSIONAL VIBRATION = %.2 f
     Hz',Fn)
```

Scilab code Exa 11.13 THE RANGE OF SPEED

```
//CHAPTER 11 ILLUSRTATION 13 PAGE NO 300
//TITLE:VIBRATIONS
//FIGURE 11.21
clc
clear
//
    ============================================================
//INPUT DATA
PI=3.147
g=9.81//
    ACCELERATION DUE TO GRAVITY IN N /m^2
D=.015//
    DIAMETER OF SHAFT IN m
L=1.00//
    LENGTH OF SHAFT IN m
M=15//
    MASS OF SHAFT IN Kg
W=M*g
e=.0003//
    ECCENTRICITY IN m
E=200*10^9//                                    YOUNGS
     MODUKUS OF SHAFT MATERIAL IN Pascals
f=70*10^6//
    PERMISSIBLE STRESS IN N/m^2
//
```

```
I=PI*D^4/64//                    MOMENT OF INERTIA OF SHAFT IN m^4
DELTA=W*L^3/(192*E*I)//          STATIC DEFLECTION IN m
Fn=.4985/(DELTA)^.5//            NATURAL FREQUENCY OF TRANSVERSE VIBRATION
Nc=Fn*60//                       CRITICAL SPEED OF SHAFT IN rpm
M1=16*f*I/(D*g*L)
W1=M1*g//                        ADDITIONAL LOAD ACTING
y=W1/W*DELTA//                   ADDITIONAL DEFLECTION DUE TO W1
N1=Nc/(1+e/y)^.5//               MIN SPEED IN rpm
N2=Nc/(1-e/y)^.5//               MAX SPEED IN rpm
//
printf('CRITICAL SPEED OF SHAFT = %.3f rpm\n THE RANGE OF SPEED IS FROM %.3f rpm TO %.3f rpm',Nc,N1,N2)
```

Chapter 12

balancing of reciprocating masses

Scilab code Exa 12.1 Magnitude of balance mass required

```
//CHAPTER 12 ILLUSRTATION 1 PAGE NO 310
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
N=250//                speed of the reciprocating
   engine in rpm
s=18//               length of stroke in mm
mR=120//              mass of reciprocating parts in
   kg
m=70//               mass of revolving parts in kg
r=.09//                radius of revolution of
   revolving parts in m
b=.15//               distance at which balancing
   mass located in m
c=2/3//              portion of reciprocating mass
   balanced
teeta=30//            crank angle from inner dead
   centre in degrees
```

```
//==================================
B=r*(m+c*mR)/b//                balance mass required
   in kg
w=2*pi*N/60//      angular speed in rad/s
F=mR*w^2*r*(((1-c)^2*(cosd(teeta))^2)+(c^2*(sind(
   teeta))^2))^.5//       residual unbalanced forces
   in N
printf('Magnitude of balance mass required= %.0f kg\
   n Residual unbalanced forces= %.3f N',B,F)
```

Scilab code Exa 12.2 swaying couple

```
//CHAPTER 12 ILLUSRTATION 2 PAGE NO 310
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
g=10//     acceleration due to gravity approximately
   in m/s^2
mR=240//     mass of reciprocating parts per cylinder
    in kg
m=300//      mass of rotating parts per cylinder in
   kg
a=1.8//distance between cylinder centres in m
c=.67//    portion of reciprocating mass to be
   balanced
b=.60//        radius of balance masses in m
r=24//        crank radius in cm
R=.8//radius of thread of wheels in m
M=40
//==========================================
Ma=m+c*mR//              total mass to be balanced in
   kg
mD=211.9//       mass of wheel D from figure in kg
mC=211.9//.....  mass of wheel C from figure in kg
```

```
theta=171//      angular position of balancing mass C
    in degrees
Br=c*mR/Ma*mC//        balancing mass for
   reciprocating parts in kg
w=(M*g^3/Br/b)^.5//    angular speed in rad/s
v=w*R*3600/1000// speed in km/h
S=a*(1-c)*mR*w^2*r/2^.5/100/1000//    swaying couple
   in kNm
printf('speed=%.3f kmph\n swaying couple=%.3f kNm',v
   ,S)
```

Scilab code Exa 12.3 swaying couple

```
//CHAPTER 12 ILLUSRTATION 3 PAGE NO 313
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
g=10//     acceleration due to gravity approximately
   in m/s^2
a=.70//distance between cylinder centres in m
r=60// crank radius in cm
m=130//mass of rotating parts per cylinder in kg
mR=210// mass of reciprocating parts per cylinder in
    kg
c=.67// portion of reciprocating mass to be balanced
N=300//e2engine speed in rpm
b=.64//        radius of balance masses in m
//==================================================
Ma=m+c*mR//              total mass to be balanced in
   kg
mA=100.44//          mass of wheel A from figure in
   kg
Br=c*mR/Ma*mA//        balancing mass for
   reciprocating parts in kg
```

```
H=Br*(2*pi*N/60)^2*b//    hammer blow in N
w=(2*pi*N/60)//     angular speed
T=2^.5*(1-c)*mR*w^2*r/2/100//tractive effort in N
S=a*(1-c)*mR*w^2*r/2/2^.5/100//    swaying couple in
   Nm

printf('Hammer blow=%.3f in N\n tractive effort= %.3
    f in N\n swaying couple= %.3f in Nm',H,T,S)
```

Scilab code Exa 12.4 unbalanced primary couple

```
//CHAPTER 12 ILLUSRTATION 4 PAGE NO 314
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
mR=900//    mass of reciprocating parts in kg
N=90//      speed of the engine in rpm
r=.45//crank radius in m
cP=.9*mR*(2*pi*N/60)^2*r*2^.5/1000//     maximum
    unbalanced primary couple in kNm
printf('maximum unbalanced primary couple=%.3f  k Nm
    ',cP)
```

Scilab code Exa 12.5 maximum unbalanced secondary force

```
//CHAPTER 12 ILLUSRTATION 5 PAGE NO 315
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
mRA=160//    mass of reciprocating cylinder A in kg
mRD=160//    mass of reciprocating cylinder D in kg
```

```
r=.05// stroke lenght in m
l=.2// connecting rod length in m
N=450// engine speed in rpm
//=================================
theta2=78.69// crank angle between A & B
    cylinders in degrees
mRB=576.88// mass of cylinder B in kg
n=l/r// ratio between connecting rod length and
    stroke length
w=2*pi*N/60// angular speed in rad/s
F=mRB*2*w^2*r*cosd(2*theta2)/n
printf('Maximum unbalanced secondary force=%.3f N in
     anticlockwise direction thats why - sign',F)
```

Scilab code Exa 12.6 hammer blow

```
//CHAPTER 12 ILLUSRTATION 6 PAGE NO 316
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
rA=.25// stroke length of A piston in m
rB=.25// stroke length of B piston in m
rC=.25// stroke length C piston in m
N=300// engine speed in rpm
mRL=280// mass of reciprocating parts in inside
    cylinder kg
mRO=240// mass of reciprocating parts in outside
    cylinder kg
c=.5// portion ofreciprocating masses to be
    balanced
b1=.5// radius at which masses to be balanced in m
//==========================
mA=c*mRO// mass of the reciprocating parts to be
    balanced foreach outside cylinder in kg
```

```
mB=c*mRL//    mass of the reciprocating parts to be balanced foreach inside cylinder in kg
B1=79.4//          balancing mass for reciprocating parts in kg
w=2*pi*N/60//   angular speed in rad/s
H=B1*w^2*b1//   hammer blow per wheel in N
printf('Hammer blow per wheel= %.3f N',H)
```

Scilab code Exa 12.7 swaying couple

```
//CHAPTER 12 ILLUSRTATION 7 PAGE NO 318
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
mR=300//    reciprocating mass per cylinder in kg
r=.3//   crank radius in m
D=1.7//  driving wheel diameter in m
a=.7//  distance between cylinder centre lines in m
H=40//  hammer blow in kN
v=90//   speed in kmph
//==========================================
R=D/2//      radius of driving wheel in m
w=90*1000/3600/R//         angular velocity in rad/s
//Br*b=69.625*c  by mearument from diagram
c=H*1000/(w^2)/69.625//   portion of reciprocating mass to be balanced
T=2^.5*(1-c)*mR*w^2*r//   variation in tractive effort in N
M=a*(1-c)*mR*w^2*r/2^.5//     maximum swaying couple in N-m
printf('portion of reciprocating mass to be balanced =%.3f\n variation in tractive effort=%.3f N\n maximum swaying couple=%.3f N-m',c,T,M)
```

Scilab code Exa 12.8 unbalanced secondary couple

```
//CHAPTER 12 ILLUSRTATION 8 PAGE NO 320
//TITLE:Balancing of reciprocating of masses
clc
clear
pi=3.141
N=1800//      speed of the engine in rpm
r=6//     length of crank in cm
l=24//    length of connecting rod in cm
m=1.5//   mass of reciprocating cylinder in kg
//==========================
w=2*pi*N/60//        angular speed in rad/s
UPC=.019*w^2//      unbalanced primary couple in N-m
n=l/r//   ratio of length of crank to the connecting rod
USC=.054*w^2/n//    unbalanced secondary couple in N-m
printf('unbalanced primary couple= %.3f N-m\n unbalanced secondary couple=%.3f N-m',UPC,USC)
```