Scilab Textbook Companion for Engineering Mechanics: Dynamics by J. L. Meriam, l. G. Kraige[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Introduction to Dynamics

Scilab code Exa 1.1 The mass of the module in both slugs and kilograms

```
// SAMPLE PROBLEM 1/1
clc;funcprot(0);
// Given data
W=100;// lb
theta=45;// degree
h=200;// mi
R=3959;// mi
g_f=32.1740;// ft/sec^2
g_m=9.80655;// m/s^2
g_0=32.234;// ft/sec^2
m_E=4.095*10^23;// lbf-s^2/ft
G=3.439*10^-8;// ft^4/(lbf-s^4)

// Calculation
// (a)
m_a=W/g_f;// slugs
W_a=W*4.4482;// N
m=W_a/g_m;// kg
printf("\n(a)The mass of the module in slugs,m=%1.2f
    slugs \n   The weight of the module in newtons,W
   =%3.0f N \n   The mass of the module in kilograms
```

```
,m=%2.1f",m_a,W_a,m);
// Again using the table inside the front cover, we have
m=W*0.45359;// kg
// (b)
g_h=(g_0*((R^2)/(R+h)^2));
W_h=m_a*g_h;
printf("\n(b)The weight at an altitude of 200 miles is then,W_h=%2.1f lb",W_h);
W_h=W_h*4.4482;
printf("\n    The weight at an altitude of 200 miles is in newton,W_h=%3.0f N",W_h);
W_h=(G*m_E*m_a)/((R+h)*5280)^2;
// (c)
// The weight of an object (the force of gravitational attraction) does not depend on the motion of the object. Thus the answers for part (c) are the same as those in part (b).
printf("\n(c)The weight of the module in both pounds and newtons,W_h=%2.1f lb (or) %3.0f N",W_h,W_h*4.4482);
```

Chapter 2

Kinematics of Particles

Scilab code Exa 2.1 The net displacement of the particle

```
// Example 2_1
clc;funcprot(0);
// Given data
// s=2t^3-24t+6;
v_a=72;// Velocity in m/s
v_b=30;// Velocity in m/s
t_0=1;// s
t_1=4;// s

// Calculation
// v=6t^2-24;
// a=12t;
// (a)
t=sqrt((v_a+24)/6);// Time in s
// (b)
a=sqrt((v_b+24)/6);// Time in s
// (c)
s4=((2*t_1^3)-(24*t)+6);// m
s1=((2*t_0^3)-(24*t_0)+6)// m;
deltaS=s4-s1;// The net displacement during the specified interval in m
```

```
printf("\n(a)The time required for the particle to reach a velocity of 72 m/s from its initial condition at t=0 is %1.0f s.\n(b)The acceleration of the particle a=%2.0f m/s^2 \n(c)The net displacement,deltaS=%2.0f m",t,a,deltaS);
```

Scilab code Exa 2.2 The maximum positive x coordinate reached by the particle

```
// Example 2_2
clc;funcprot(0);
// Given data
v_x=50;// The initial velocity in ft/sec
a_x=-10;// The acceleration in ft/sec^2
t_0=8;// s
t_1=12;// s

// Calculation
// v_x=90-10t; ft/sec
v_x0=(90-(10*t_0));// The velocity in ft/sec
v_x1=(90-(10*t_1));// The velocity in ft/sec
// x=-5t^2+90t-80; ft
x_0=(-5*t_0^2)+(90*t_0)-80;// ft
x_1=(-5*t_1^2)+(90*t_1)-80;// ft
// The maximum positive x-coordinate is,then, the value of x for t=9 sec which is
t=9;// sec
x_max=(-5*t^2)+(90*t)-80;// ft
printf("\nThe velocity of the particle for the conditions of t=8 sec and t=12 sec,v_x=%2.0f ft/sec & v_x=%2.0f ft/sec \nThe x-coordinate of the particle for the conditions of t=8 sec and t=12 sec, x=%3.0f ft & x=%3.0f ft \nThe maximum positive x-coordinate reached by the particle, x_max=%3.0f ft",v_x0,v_x1,x_0,x_1,x_max)
```

Scilab code Exa 2.5 velocity and acceleration

```
// Example 2_5
clc;funcprot(0);
// Given data
// v_x=50-60t;
// y=100-4t^2;
// where v_x is in meters per second, y is in meters, and t is in seconds.

// Calculation
// x=50t-8t^2;
a_x=-16;// The x-component of the acceleration in m/s^2
// v_y=-8t; The y-component of the velocity in m/s
a_y=-8;// The y-component of the acceleration in m/s^2
// When y=0,
t=sqrt(100/4);
v_x=50-(16*t);
v_y=-8*(t);
v=sqrt((v_x.^2)+(v_y.^2));// m/s
a=sqrt(a_x.^2+a_y.^2);// m/s^2
printf("\nThe velocity,v=%2.0fi+(%2.0fj) m/s \nThe acceleration,a=%2.0fi+(%1.0fj) m/s^2",v_x,v_y,a_x,a_y);
y=[0,20,40,60,80,100];// m
for(i=1:6)
    t(i)=sqrt((100-y(i))/4);// s
    x(i)=((50*t(i))-(8*t(i).^2));// m
    v_x(i)=((50*t(i)-(8*t(i).^2)));// m/s
    v_y(i)=(-8*t(i));// m/s
    v=sqrt((v_x.^2)+(v_y.^2));// m/s
    a=sqrt(a_x.^2+a_y.^2);// m/s^2
```

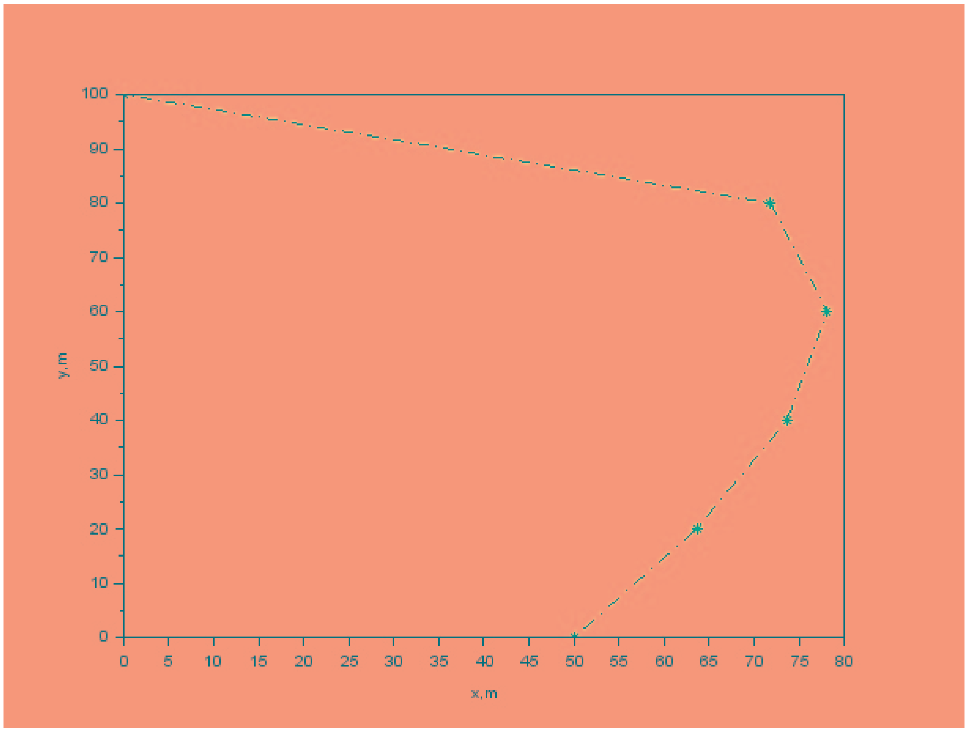

Figure 2.1: velocity and acceleration

```
end
plot(x',y,'-.*');
xlabel('x,m');
ylabel('y,m');
```

Scilab code Exa 2.6 The velocity with which the projectile strikes the ground

```
// Example 2_6
clc;funcprot(0);
// Given data
```

```
v_0=80;// The launch speed in ft/sec
theta=35;// The launch angle in degree
m=8;// lb
g=32.2;// The acceleration due to gravity in ft/sec^2
y_0=6;// ft
x_0=0;// ft
x=100+30;// ft

// Calculation
v_x0=v_0*cosd(theta);// ft/sec
t=(x-x_0)/v_x0;// s
v_y0=v_0*sind(theta);// ft/sec
y=(y_0+(v_y0*t))-((1/2)*g*t^2);// ft
// (a)
// We now find the flight time by setting
y_01=20;// ft
function[X]=time(y)
    X(1)=((y_0+(v_y0*y(1))-((1/2)*g*y(1)^2)))-y_01;
endfunction
y=[10];
z=fsolve(y,time);
t_f=z(1);// s
x=x_0+(v_x0*t_f);// ft
printf("\n(a)The time duration of the flight,t_f=%1.2f s",t_f);
//(b)
printf("\n(b)Thus the point of first impact is (x,y)=(%3.0f,%2.0f)ft",x,y_01);
// (c)
v_y=0;// ft
h=((v_y0^2-v_y^2)/(2*g))+6;// ft
printf("\n(c)The maximum height above the horizontal field attained by the ball,h=%2.1f ft",h);
// (d)
v_x=v_x0;// ft/sec
v_y=v_y0-(g*t_f);// ft/sec
printf("\n(d)The impact velocity,v=%2.1f i+(%2.1f j)
```

```
ft/sec",v_x,v_y);
x=100+30;// ft (given)
v_0=75;// ft/sec (given)
v_x0=v_0*cosd(theta);// ft/sec
t=(x-x_0)/v_x0;// s
v_y0=v_0*sind(theta);// ft/sec
y=(y_0+(v_y0*t))-((1/2)*g*t^2);// ft
printf("\n   The point of impact is (x,y)=(%3.0f,%2.1f)ft",x,y);
```

Scilab code Exa 2.7 The total acceleration at C

```
// Example 2_7
clc;funcprot(0);
// Given data
a=3;// m/s^2
v_A=100;// km/h
v_C=50;// km/h
s=120;// m

// Calculation
v_A=v_A*(1000/3600);// The velocity in m/s
v_C=v_C*(1000/3600);// The velocity in m/s
a_t=(1/(2*s))*(v_C.^2-v_A.^2);// The acceleration in m/s^2
// (a) Condition at A.
a_n=sqrt(a.^2-(a_t).^2);// The acceleration in m/s^2
rho_A=v_A.^2/a_n;// The radius of curvature at A in m
// (b) Condition at B.
a_n=0;// m/s^2
a_b=a_n+a_t;// The acceleration at the inflection point B in m/s^2
// (c) Condition at C.
rho=150;// The radius of curvature of the hump at C
```

```
in m
a_n=v_C.^2/rho;// The normal acceleration in m/s^2
a=sqrt(a_n.^2+a_t.^2);// The total acceleration at C in m/s^2
printf("\n(a)The radius of curvature at A,rho=%3.0f m \n(b)The acceleration at the inflection point B,a=%1.2f m/s^2 \n(c)The total acceleration at C,a=%1.2f m/s^2",rho_A,a_b,a)
```

Scilab code Exa 2.8 The vector expression for the total acceleration a of the rocket

```
// Example 2_8
clc;funcprot(0);
// Given data
g=30;// The acceleration due to gravity in ft/sec^2
theta=15;// The direction of its trajectory in degree
v=12000;// The velocity in mi/hr
a_x=20;// The horizontal component of acceleration in ft/sec^2
a_y=g;// The downward acceleration component in ft/sec^2

// Calculation
a_n=(a_y*cosd(theta))-(a_x*sind(theta));// The normal component of acceleration in ft/sec^2
a_t=(a_y*sind(theta))+(a_x*cosd(theta));// The tangential component of acceleration in ft/sec^2
// (a)
v=v*44/30;// ft/sec
rho=v^2/a_n;// The radius of curvature in ft
// (b)
vdot=a_t;// The t-component of acceleration in ft/sec^2
```

```
// (c)
betadot=v/rho;// The angular rate of line GC in rad/sec
// (d)
a=[a_n,a_t];// The total acceleration in ft/sec^2
printf("\n(a) The radius of curvature,rho=%2.2e ft \n(b)The t-component of acceleration,v_dot=%2.1f ft/sec^2 \n(c)The angular rate of line GC,betadot=%2.2e rad/sec \n(d)The total acceleration,a=%2.1f e_n+%2.1f e_t ft/sec^2",rho,vdot,betadot,a(1),a(2));
```

Scilab code Exa 2.9 The magnitudes of the velocity and acceleration of the slider

```
// Example 2_9
clc;funcprot(0);
// Given data
// theta=0.2t+0.02t^3;
// r=0.2+0.04t^2;
t=3;// s

// Calculation
r_3=0.2+(0.04*t^2);// m
rdot_3=0.08*t;// m/s
rdotdot_3=0.08;// m/s^2
theta_3=(0.2*t)+(0.02*t^3);// rad
thetadot_3=0.2+(0.06*t^2);// rad/s
thetadotdot_3=0.12*t;// rad/s^2
v_r=rdot_3;// m/s
v_theta=r_3*thetadot_3;// m/s
v=sqrt(v_r^2+v_theta^2);// m/s
a_r=rdotdot_3-(r_3*thetadot_3^2);// m/s^2
a_theta=((r_3*thetadotdot_3)+(2*rdot_3*thetadot_3));// m/s^2
```

```
a=sqrt(a_r^2+a_theta^2);// m/s^2
printf("\nThe magnitudes of the velocity and acceleration of the slider, v=%0.3f m/s and a=%0.3f m/s^2",v,a);
```

Scilab code Exa 2.10 The velocity v of the rocket

```
// Example 2_10
clc;funcprot(0);
// Given data
theta_i=30;// degrees
r=25*10^4;// ft
rdot=4000;// ft/sec
theta=0.80;// deg/sec
g=31.4;// ft/sec^2

// Calculation
v_r=rdot;// ft/sec
v_theta=r*(theta*%pi/180);// ft/sec
v=sqrt(v_r^2+v_theta^2);// ft/sec
a_r=-g*cosd(theta_i);// ft/sec^2
a_theta=g*sind(theta_i);// ft/sec^2
rdotdot=a_r+(r*(theta*(%pi/180))^2);// ft/sec^2
thetadotdot=(a_theta-(2*rdot*theta*%pi/180))/r;// ft/sec^2
printf("\nThe velocity of the rocket,v=%4.0f ft/sec \nrdotdot=%2.1f ft/sec^2 and thetadotdot=%1.2e rad/sec^2",v,rdotdot,thetadotdot);
```

Scilab code Exa 2.12 The velocity of P into cylindrical coordinate components

```
// Example 2_12
```

```
clc;funcprot(0);
// Given data
v_0=250;// km/h
theta_i=15;// degree
a=0.8;// m/s^2
t=60;// seconds
s_0=0;// m
x=3000;// m

// Calculation
// (a)
v_0=v_0/3.6;// m/s
v=v_0+(a*t);// m/s
s=s_0+(v_0*t)+((1/2)*a*t^2);// m
y=s*cosd(theta_i);// m
theta=atand(y/x);// degree
r=sqrt(x.^2+y.^2);// m
v_xy=v*cosd(theta_i);// m/s
v_r=v_xy*sind(theta);// m/s
v_theta=v_xy*cosd(theta);// m/s
thetadot=v_theta/r;// rad/s
zdot=v*sind(theta_i);// m/s
v_z=zdot;// m/s
// (b)
z=y*tand(theta_i);// m
phi=atand(z/r);// degree
R=sqrt(r^2+z^2);// m
v_R=(v_r*cosd(phi))+(zdot*sind(phi));// m/s
v_phi=(zdot*(cosd(phi)))-(v_r*sind(phi));// m/s
phidot=v_phi/R;// m/s
printf("\n(a)v_r=%2.1f m/s \n    thetadot=%1.2e rad/s
    \n    zdot=v_z=%2.1f m/s \n(b)v_R=%3.1f m/s \n
    thetadot=%1.2e rad/s \n    phidot=%1.3e rad/s",v_r
    ,thetadot,zdot,v_R,thetadot,phidot);
```

Scilab code Exa 2.13 The true velocity of B

```
// Example 2_13
clc;funcprot(0);
// Given data
v_A=800;// km/h
theta_1=45;// degree
theta_2=60;// degree
theta_3=75;// degree

// Calculation
// (I) Graphical.
v_BA=586;// km/h
v_B=717;// km/h
printf("\nv_BA=%3.0f km/h and v_B=%3.0f km/h",v_BA,v_B);
// (II) Trigonometric.
v_B=(sind(theta_2)*v_A)/sind(theta_3);// km/h
printf("\nv_B=%3.0f km/h",v_B);
// (III) Vector Algebra
v_B=[(v_B*cosd(theta_1)),(v_B*sind(theta_1))];// km/h
v_BA=[-(v_BA*cosd(theta_2)),(v_BA*sind(theta_2))];// km/h
function[X]=velocity(y)
    X(1)=(v_A-(y(2)*cosd(theta_2)))-(y(1)*cosd(theta_1));
    X(2)=(y(2)*sind(theta_2))-(y(1)*sind(theta_1));
endfunction
y=[100,100];
z=fsolve(y,velocity);
v_BA=z(1);// km/h
v_B=z(2);// km/h
printf("\nv_AB=%3.0f km/h and v_B=%3.0f km/h",v_BA,v_B);
```

Scilab code Exa 2.14 The velocity and acceleration

```
// Example 2_14
clc;funcprot(0);
// Given data
v_A=45;// mi/hr
v_B=30;// mi/hr
a_A=3;// ft/sec^2
theta_1=30;// degree
theta_2=60;// degree
rho=440;// The radius of curvature in ft

// Calculation
// Velocity
v_A=v_A*(5280/3600);// ft/sec
v_B=v_B*(5280/3600);// ft/sec
// By the application of the law of cosines and the
   law of sines gives
v_BA=sqrt(v_A^2+v_B^2-(2*v_A*v_B*cosd(theta_2)));//
   ft/sec
theta=asind((v_B*sind(theta_2))/v_BA);// degree
// Acceleration
a_B=(v_B)^2/rho;// ft/sec^2
a_BAx=a_B*cosd(theta_1)-a_A;// ft/sec^2
a_BAy=a_B*sind(theta_1);// ft/sec^2
a_BA=sqrt(a_BAx^2+a_BAy^2);// ft/sec^2
beta=asind((a_B*sind(theta_1))/a_BA);// degree
printf("\nv_BA=%2.1f ft/sec \ntheta=%2.1f degree \
   na_AB=%1.2f ft/sec^2 \nbeta=%2.1f degree",v_BA,
   theta,a_BA,beta);
```

Scilab code Exa 2.15 The velocity of B

```
// Example 2_15
clc;funcprot(0);
// Given data
v_A=0.3;// m/s

// Calculation
// Solution (I).
// v_A=y_A ,v_B=y_B
v_B=-(2*v_A)/3;// m/s
printf("\nThe velocity of B,v_B=%0.1f m/s",v_B);
// Solution (II).
v_B=abs((2/3)*v_A);// m/s
printf("\nThe velocity of B,v_B=%0.1f m/s (upward)",
   v_B);
```

Chapter 3

Kinetics of particles

Scilab code Exa 3.1 The reading R of the scale in newtons

```
// SAMPLE PROBLEM 3/1
clc;clear;funcprot(0);
// Given data
m=75;// kg
T=8300;// The tension in the hoisting cable in N
g=9.81;// The acceleration due to gravity in m/s^2
m_ems=750;// The total mass of the elevator, man and scale in kg
t_0=0;// s
t_1=3;// s

// Calcaulation
// SigmaF_y=m*a_y;
a_y=(T-(m_ems*g))/m_ems;// m/s^2
// SigmaF_y=m*a_y;
R=((m*a_y)+(m*g));// N
v=(1.257*t_1)-(1.257*t_0);// m/s
printf("\nThe equal and opposite reaction,R=%3.0f N \nThe upward velocity of the elevator,v=%1.2f m/s ",R,v);
```

Scilab code Exa 3.2 The acceleration of the car

```
// SAMPLE PROBLEM 3/2
clc;clear;funcprot(0);
// Given data
m=200;// The mass of the small inspection car in kg
T=2.4;// kN
x=12;// adjacent side
y=5;// opposite side
r=13;// hypotenuse side
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
W=(m*g)/1000;// The weight in N
// SigmaF_y=0;
P=(T*(y/r))+(W*(x/r));// The total force exerted by
    the supporting cable on the wheels in N
// SigmaF_x=ma_x
a=((T*10^3*(x/r))-(W*10^3*(y/r)))/m;// The
    acceleration of the car in m/s^2
printf("\nThe total force exerted by the supporting
    cable on the wheels,P=%1.2f kN \nThe acceleration
     of the car,a=%1.2f m/s^2",P,a);
```

Scilab code Exa 3.3 The velocity of the block as it hits the ground at B

```
// SAMPLE PROBLEM 3/3
clc;clear;funcprot(0);
// Given data
m_A=250;// The mass of concrete block A in lb
m=400;// lb
theta=30;// degree
```

```
mu_k=0.5;// The coefficient of kinetic friction
    between the log and the ramp
x=20;// ft
g=32.2;// The acceleration due to gravity in ft/sec
    ^2

// Calculation
// SigmaF_y=0;
N=m*cosd(theta);// lb
// SigmaF_x=ma_x;
function[X]=acceleration(y)
    X(1)=0-((2*y(2))+y(3));
    X(2)=((mu_k*N)-(2*y(1))+(m*sind(theta)))-((m/g)*
        y(2));
    X(3)=(m_A-y(1))-((m_A/g)*y(3));
endfunction
y=[100,1,1];
z=fsolve(y,acceleration);
T=z(1);// lb
a_A=z(3);// ft/sec^2
a_C=z(2);// ft/sec^2
v_A=sqrt(2*a_A*x);// ft/sec
printf("\nThe velocity of the block as it hits the
    ground at B,v_A=%2.2f ft/sec",v_A);
```

Scilab code Exa 3.4 The time t required for it to reduce its speed and the corresponding travel distance x

```
// SAMPLE PROBLEM 3/4
clc;clear;funcprot(0);
// Given data
m=10;// The mass in kg
v=2;// The speed in m/s
R=8;// N

```

```
// Calculation
k=R/v^2;// N.s^2/m^2
// SigmaF_x=ma_x;
v_0=v;// m/s
v=v_0/2;// m/s
t=((1/v)-(1/2));// The time in s
t_0=0;// s
t_1=2.5;// s
x=integrate('10/(5+(2*t))','t',t_0,t_1);
printf("\nThe corresponding travel distance,x=%1.2f m",x);
```

Scilab code Exa 3.8 The total horizontal force exerted by the road on the tires

```
// SAMPLE PROBLEM 3/8
clc;clear;funcprot(0);
// Given data
m=1500;// The mass of the car in kg
v_A=100;// The velocity in km/h
v_C=50;// The velocity in km/h
rho_A=400;// The radius of curvature in m
rho_C=80;// The radius of curvature in m
delta_s=200;// m

// Calculation
a_t=abs((((v_C/3.6)^2)-((v_A/3.6)^2))/(2*delta_s));// The tangential acceleration in m/s^2
a_na=((v_A/3.6)^2)/rho_A;// The normal components of acceleration at A in m/s^2
a_nb=0;// The normal components of acceleration at B in m/s^2
a_nc=((v_C/3.6)^2)/rho_C;// The normal components of acceleration at C in m/s^2
F_t=m*a_t;// N
```

```
F_na=m*a_na;// N
F_nb=m*a_nb;// N
F_nc=m*a_nc;// N
F_a=sqrt(F_na^2+F_t^2);// The total horizontal force
    acting on the tires at A in N
F_b=sqrt(F_nb^2+F_t^2);// The total horizontal force
    acting on the tires at B in N
F_c=sqrt(F_nc^2+F_t^2);// The total horizontal force
    acting on the tires at C in N
printf("\nAt A,F=%4.0f N \nAt B,F=%4.0f N \nAt C,F=
   %4.0f N",F_a,F_b,F_c);
```

Scilab code Exa 3.9 The magnitude v of the velocity required for the spacecraft S

```
// SAMPLE PROBLEM 3/9
clc;clear;funcprot(0);
// Given data
h=200;// The altitude in mi
R=3959;// mi
g=32.234;// The acceleration due to gravity in ft/
   sec^2

// Calculation
// SigmaF_n=ma_n;
v=(R*5280)*sqrt(g/((R+h)*5280));// ft/sec
printf("\nThe velocity required for the spacecraft,v
   =%5.0f ft/sec",v);
```

Scilab code Exa 3.11 The velocity v of the crate

```
// SAMPLE PROBLEM 3/11
clc;clear;funcprot(0);
```

```
// Given data
m=50;// kg
v_1=4;// m/s
mu_k=0.30;// The coefficient of kinetic friction
g=9.81;// The acceleration due to gravity in m/sec^2
s=10;// m
theta=15;// degree
R=474;// N

// Calculation
U_12=((m*g)*s*sind(theta))-(mu_k*R*(s));// The total
    work done on the crate during the motion in J
v_2=sqrt((((1/2)*m*v_1^2)+U_12)/((1/2)*m));// The
    velocity of the crate in m/s
printf("\nThe velocity of the crate,v_2=%1.2f m/s",
    v_2);
```

Scilab code Exa 3.12 The work done by the friction force acting on the crate

```
// SAMPLE PROBLEM 3/12
clc;clear;funcprot(0);
// Given data
m=80;// kg
v=72;// km/h
s=75;// m
g=9.81;// The acceleration due to gravity in m/sec^2
mu_sa=0.30;// The coefficient of static friction
mu_ka=0.28;// The coefficient of kinetic friction
mu_sb=0.25;// The coefficient of static friction
mu_kb=0.20;// The coefficient of kinetic friction

// Calculation
// (a)
a_1=(v/3.6)^2/(2*s);// m/s^2
```

```
F=m*a_1;// The friction force on the block in N
U_12=F*s;// The work done in J
printf("\n(a)The work done by the friction force
    acting on the crate,U_12=%5.0f J (or) %2.0f kJ",
    U_12,U_12/1000);
// (b)
F_1=mu_sb*m*g;// N
F_2=mu_kb*m*g;// N
F=F_2;// N
a=F/m;// The acceleration in m/s^2
s=(a/a_1)*s;// The displacement of a crate in m
U_12=F*s;// The work done in J
printf("\n(b)The work done by the friction force
    acting on the crate,U_12=%4.0f J (or) %1.2f kJ",
    U_12,U_12/1000);
```

Scilab code Exa 3.13 The velocity v of the block as it reaches position B

```
// SAMPLE PROBLEM 3/13
clc;clear;funcprot(0);
// Given data
m=50;// The mass of the block in kg
F=300;// N
x_1=0.233;// m
k=80;// The spring stifness in N/m
x=1.2;// m
y=0.9;// m

// Calculation
x_2=x_1+x;// m
U_12=(1/2)*k*(x_1^2-x_2^2);// The work done by the
    spring force acting on the block in J
s=sqrt(x^2+y^2)-y;// m
W=F*s;// The work done in J
T_1=0;// J
```

```
v=sqrt(((U_12+W)*2)/m);// m/s
printf("\nThe velocity of the block as it reaches position B,v=%1.2f m/s",v);
```

Scilab code Exa 3.14 The corresponding instantaneous acceleration a of the log

```
// SAMPLE PROBLEM 3/14
clc;clear;funcprot(0);
// Given data
F=800;// lb
v=4;/// ft/sec
P=6;// The power output of the winch in hp
P_i=8;// hp
theta=30;// degree
g=32.2;// The acceleration due to gravity in ft/sec^2

// Calculation
N=F*cosd(theta);// lb
// SigmaF_x=0;
T=(P*550)/v;// The tension in the cable in N
mu_k=(T-(F*sind(theta)))/N;// The coefficient of kinetic friction
T=(P_i*550)/v;// lb
a=(T-(N*mu_k)-(F*sind(theta)))*(g/F);// The acceleration in ft/sec^2
printf("\nThe corresponding instantaneous acceleration of the log,a=%2.2f ft/sec^2",a);
```

Scilab code Exa 3.15 The velocity of the satellite as it reaches point B

```
// SAMPLE PROBLEM 3/15
```

```
clc;clear;funcprot(0);
// Given data
h_1=500;// km
v_1=30000;// km/h
h_2=1200;// km
R=6371;// km
g=9.81;// The acceleration due to gravity in m/sec^2

// Calculation
v_2=sqrt((v_1/3.6)^2+((2*g*(R*10^3)^2)*((10^-3/(R+h_2))-(10^-3/(R+h_1)))));
printf("\nThe velocity of the satellite as it reaches point B,v_2=%4.0f m/s (or) v_2=%5.0f km/h",v_2,v_2*3.6);
```

Scilab code Exa 3.16 The velocity of the slider as it passes position 2

```
// SAMPLE PROBLEM 3/16
clc;clear;funcprot(0);
// Given data
mg=6;// lb
k=2;// lb/in
g=32.2;// The acceleration due to gravity in ft/sec^2
h=24;// in
x_1=24/12;// ft
x_2=(((24*sqrt(2))/12)-(24/12));// ft

// Calculation
// The reaction of the rod on the slider is normal to the motion and does no work.
T_1=0;// ft-lb
U_12=0;// ft-lb
// We define the datum to be at the level of position 1, so that the gravitational potential
```

```
   energies are
V_1g=0;// ft-lb
V_2g=-(mg)*(h/12);// ft-lb
V_1e=(1/2)*(k*12)*(x_1)^2;// ft-lb
V_2e=(1/2)*(k*12)*(x_2)^2;// ft-lb
v_2=sqrt(((T_1+(V_1g+V_1e)+U_12)-(V_2g+V_2e))*(2*(g/
   mg)));// ft/sec
printf("\nThe velocity of the slider as it passes
   position 2,v_2=%2.1f ft/sec",v_2);
```

Scilab code Exa 3.17 The velocity of the slider as it passes point C

```
// SAMPLE PROBLEM 3/17
clc;clear;funcprot(0);
// Given data
m=10;// kg
k=60;// N/m
F=250;// N
theta=30;// degree
ABbar=1.5;// m
BCbar=0.9;// m
g=9.81;// The acceleration due to gravity in m/sec^2
d_AC=1.2;// The distance in m
d_BC=0.9;// The distance in m

// Calculation
s=ABbar-BCbar;// m
U_ac=F*s;// J
V_Ag=0;// The initial gravitational potential energy
    in J
T_A=(1/2)*m*V_Ag^2;// N.m
V_Cg=m*g*(d_AC*sind(theta));// The final
   gravitational potential energy in J
x_A=s;// m
x_B=s+d_AC;// m
```

```
V_Ae=(1/2)*k*(x_A)^2;// The initial elastic potential energy in J
V_Ce=(1/2)*k*(x_B)^2;// The final elastic potential energy in J
// Substitution into the alternative work-energy equation 3/21a gives
v_c=sqrt((((T_A+V_Ag+V_Ae+U_ac)-(V_Cg+V_Ce))*2)/m);// m/s
printf("\nThe velocity of the slider as it passes point C,v_C=%0.3f m/s",v_c);
```

Scilab code Exa 3.18 The speed of particle A

```
// SAMPLE PROBLEM 3/18
clc;clear;funcprot(0);
// Given data
m_A=2;// kg
m_B=4;// kg
L=0.5;// m
K_theta=13;// N.m/rad
g=9.81;// The acceleration due to gravity in m/sec^2

// Calculation
// (a)
// T_1+V_1+U_12=T_2+V_2
function[X]=velocity(y)
    X(1)=(((1/2)*m_A*y(1)^2)+((1/2)*m_B*(y(1)/4)^2)-(m_A*g*L)-(m_B*g*(L*sqrt(2)/4))+((1/2)*K_theta*(%pi/2)^2))-0;
endfunction
y=[0.1];
v_A=fsolve(y,velocity);// m/s
printf("\nThe speed of particle A,v_A=%0.3f m/s",v_A);
// (b)
```

```
for(i=1:10)
    theta=[0,10,20,30,40,50,60,70,80,90];// degree
    // T_1+V_1+U_12=T_2+V_2
    v_A(i)=sqrt(((m_A*g*L*(1-cosd(theta(i))))+((m_B*
       g*(1/2)*[((L*sqrt(2))/2)-((2*(L/2)*sind((90-(
       theta(i)))/2)))]))-((1/2)*K_theta*(theta(i)*(
       %pi/180))^2))/(((1/2)*m_A)+((1/2)*m_B*((1/4)*
       cosd((90-(theta(i)))/2))^2)));
end
plot(theta',v_A);
xlabel('theta,deg');
ylabel('v_A,m/s');
printf("\nThe maximum value of v_A is seen to be (
   v_A)_max=1.400 m/s at theta=56.4 degree.");
```

Scilab code Exa 3.19 The magnitude of the average force R exerted by the racket on the ball

```
// SAMPLE PROBLEM 3/19
clc;clear;funcprot(0);
// Given data
v_1=50;// ft/sec
v_2=70;// ft/sec
theta=15;// degree
dt=0.02;// sec
g=32.2;// The acceleration due to gravity in ft/sec
   ^2

// Calculation
W=2/16;// N
v_1x=v_1;// ft/sec
v_2x=v_2;// ft/sec
v_1y=0;// ft/sec
```

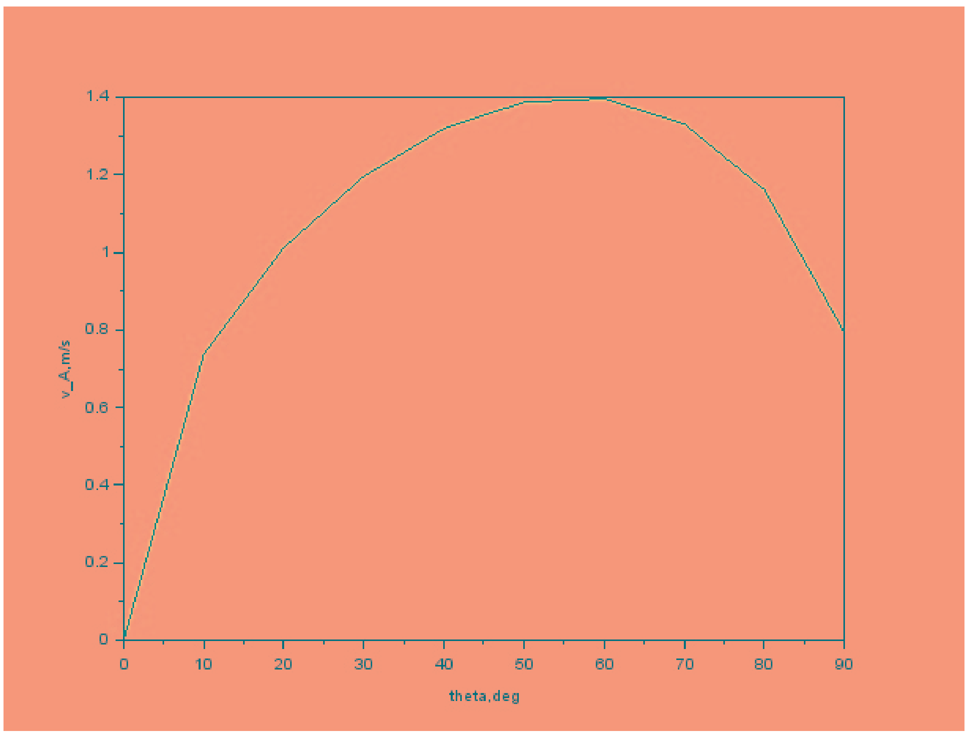

Figure 3.1: The speed of particle A

```
v_2y=v_2;// ft/sec
R_x=(((W/g)*(v_2x*cosd(theta))+((W/g)*(v_1x)))/dt;
    // lb
R_y=(((W/g)*(v_2y*sind(theta))+((W/g)*(v_1y)))/dt;
    // lb
R=sqrt(R_x^2+R_y^2);// lb
beta=atand(R_y/R_x);// degree
printf("\nThe magnitude of the average force exerted
     by the racket on the ball,R=%2.1f lb \nThe angle
     made by R with the horizontal,beta=%1.2f degree"
    ,R,beta);
```

Scilab code Exa 3.20 F and its magnitude

```
// SAMPLE PROBLEM 3/20
clc;clear;funcprot(0);
// Given data
// G=(3/2)*(t^2+3)j-((2/3)*(t^3-4))k
t=2;// sec

// Calculation
F=[3*(t),2-(2*t^2)];// [j,k] lb
F_r=sqrt(F(1)^2+F(2)^2);// lb
printf("\nF=%1.0fj+(%1.0fk)lb \nF=%1.3f lb",F(1),F
    (2),F_r);
```

Scilab code Exa 3.21 The velocity v of the particle

```
// SAMPLE PROBLEM 3/21
clc;clear;funcprot(0);
// Given data
m=0.5;// kg
v_1x=10;// m/s
```

```
v_1y=0;// m/s
t_1=1;// s
t_2=2;// s
t_3=3;// s

// Calculation
v_2x=((m*v_1x)-((4*(t_1))+(2*(t_3-t_1))))/(m);// m/s
v_2y=((m*v_1y)+((1*(t_2))+(2*(t_3-t_2))))/(m);// m/s
v_2=[v_2x,v_2y];// m/s
v_2=norm(v_2);// m/s
theta_x=180+atand(v_2y/v_2x);// degree
printf("\nThe velocity of the particle at the end of the 3-s interval,v_2=%2.0f m/s \ntheta_x=%3.1f degree",v_2,theta_x);
```

Scilab code Exa 3.22 The time at which the skip reverses its direction

```
 // SAMPLE PROBLEM 3/22
clc;funcprot(0);
// Given data
m=150;// kg
v_1=4;// m/s
t_0=0;// s
t_1=4;// s
P=600;// N
t_2=8;// s
theta=30;// degree
g=9.81;// The acceleration due to gravity in m/sec^2

// Calculation
deltat=(m*0)+((m*v_1)-((v_1*2*P)/2)+(m*g*sind(theta)))/((2*P)+(m*g*sind(theta)));// s
t_a=v_1+deltat;// s
v_2x=((m*-v_1)+((v_1*2*P)/2)+(v_1*2*P)-(m*g*sind(theta)*t_2))/m;// m/s
```

```
printf("\n(a)The time at which the skip reverses its direction ,t_a=%1.2f s \n(b)The velocity of the skip ,v_2x=%1.2f m/s",t_a,v_2x);
```

Scilab code Exa 3.23 The velocity of the block

```
// SAMPLE PROBLEM 3/23
clc;funcprot(0);
// Given data
m_1=0.050;// kg
m_2=4;// kg
v_1=600;// m/s
v_2=12;// m/s
theta=30;// degree

// Calculation
v_2=[(m_2*v_2*cosd(theta))/(m_1+m_2),((m_1*v_1)+(m_2*v_2*sind(theta)))/(m_1+m_2)];// m/s
v_x=v_2(1);// m/s
v_y=v_2(2);// m/s
V_2=sqrt((v_x^2+v_y^2));// m/s
theta=atand((v_y/v_x));// degree
printf("\nThe velocity of the block and embedded bullet immediately after impact ,v_2=%2.2fi+%2.2fj m/s \nThe final velocity and its direction are given by v_2=%2.2f m/s and theta=%2.1f degree",v_x,v_y,V_2,theta);
```

Scilab code Exa 3.24 The angular momentum about point O and the time derivative

```
// SAMPLE PROBLEM 3/24
clc;funcprot(0);
```

```
// Given data
F_z=10;// N
m=2;// kg
v_y=5;// m/s
x=3;// m
y=6;// m
z=4;// m

// Calculation
r=[x,y,z];// m
mv=[m*0,m*v_y,m*0];// (kg.m/s)
H_O1=det([r(2),r(3);mv(2),mv(3)]);// N.m/s
H_O2=-det([r(1),r(3);mv(1),mv(3)]);// N.m/s
H_O3=det([r(1),r(2);mv(1),mv(2)]);// N.m/s
H_O=[H_O1,H_O2,H_O3];// m/s
F=[0,0,F_z];// N
Hdot_O1=det([r(2),r(3);F(2),F(3)]);// N.m
Hdot_O2=-det([r(1),r(3);F(1),F(3)]);// N.m
Hdot_O3=det([r(1),r(2);F(1),F(2)]);// N.m
Hdot_O=[Hdot_O1,Hdot_O2,Hdot_O3];// N.m
printf("\nThe angular momentum H_O about point O,H_O
    =%2.0fi+(%2.0f)j+%2.0fk N.m/s \nThe time
    derivative,Hdot=%2.0fi+(%2.0f)j+%2.0fk N.m",H_O
    (1),H_O(2),H_O(3),Hdot_O(1),Hdot_O(2),Hdot_O(3));
```

Scilab code Exa 3.25 The speed of comet at the point B of closest approach to the sun

```
// SAMPLE PROBLEM 3/25
clc;funcprot(0);
// Given data
v_A=740;// m/s
r_A=6000*10^6;// km
r_B=75*10^6;// km

```

```
// Calculation
v_B=(r_A*v_A)/r_B;// m/s
printf("\nThe speed of comet at the point B of closest approach to the sun,v_B=%5.0f m/s",v_B);
```

Scilab code Exa 3.28 The percentage loss of energy due to the impact

```
// SAMPLE PROBLEM 3/28
clc;funcprot(0);
// Given data
m=800;// kg
g=9.81;// m/s^2
h=2;// m
m_p=2400;// kg
h_1=0.1;// m

// Calculation
v_r=sqrt(2*g*h);// m/s
v_ra=sqrt(2*g*h_1);// m/s
// (a)
v_pa=(((m*v_r)+0)+(m*v_ra))/m_p;// m/s
// (b)
e=(v_pa+v_ra)/(v_r+0);// The coefficient of restitution
// (c)
T=m*g*h;// J
T_a=((m*v_ra**2)/2)+((m_p*v_pa**2)/2);// J
E_l=((T-T_a)/T)*100;// The percentage loss of energy (%)
printf("\n(a)The velocity of the pile immediately after impact,v_p=%1.2f m/s \n(b)The coefficient of restitution,e=%0.3f \n(c)The percentage loss of energy due to the impact is %2.1f percentage.",v_pa,e,E_l);
```

Scilab code Exa 3.29 The rebound velocity and its angle

```
// SAMPLE PROBLEM 3/29
clc;funcprot(0);
// Given data
v_1=50;// m/s
v_2=0;// m/s
e=0.5;// The effective coefficient of restitution
theta=30;// degree

// Calculation
v_1an=e*v_1*sind(theta);// ft/sec
v_1at=v_1*cosd(theta);// ft/sec
// Assume ' as a
v_a=sqrt((v_1an)**2+(v_1at)**2);// ft/sec
theta_a=atand((v_1an/v_1at));// degree
printf("\nThe rebound velocity and its angle are
   then v_a=%2.1f ft/sec and theta_a=%2.1f degree",
   v_a,theta_a);
```

Scilab code Exa 3.30 The percentage loss of energy due to the impact

```
// SAMPLE PROBLEM 3/30
clc;funcprot(0);
// Given data
v_1=6;// m/s
v_2=0;// m/s
e=0.6;// The coefficient-of-restitution
theta=30;// degree

// Calculation
// Assume a for '
```

```
v_1n=v_1*cosd(theta);// m/s
v_1t=v_1*sind(theta);// m/s
v_2n=0;// m/s
v_2t=v_2n;// m/s
function[X]=velocity(y)
    X(1)=(v_1n+v_2n)-(y(1)+y(2));
    X(2)=(e*(v_1n+v_2n))-(y(2)-y(1));
endfunction
y=[1,1];
z=fsolve(y,velocity);
v_1an=z(1);// m/s
v_2an=z(2);// m/s
v_1at=v_1t;// m/s
v_2at=v_2t;// m/s
v_1a=sqrt((v_1an)^2+(v_1at)^2);// m/s
v_2a=sqrt((v_2an)^2+(v_2at)^2);// m/s
thetaa=atand(v_1an/v_1at);// m/s
// The kinetic energies just before and just after impact, with m=m1=m2, are
T=18;// m
T_a=13.68;// m
E_l=((T-T_a)/T)*100;// The percentage energy loss(%)
printf("\nThe final speeds of the particles v_1a=%1.2f m/s ,v_2a=%1.2f m/s \nThe angle which v_1a makes with the t-direction,theta=%2.2f degree \nThe percentage energy loss is %2.0f percentage.",v_1a,v_2a,thetaa,E_l);
```

Scilab code Exa 3.31 Compute the period for a complete orbit

```
// SAMPLE PROBLEM 3/31
clc;funcprot(0);
// Given data
h_1=2000;// The perigee altitude in km
h_2=4000;// The apogee altitude in km
```

```
h_c=2500;//The  altitude of the satellite in km
g=9.825;// The acceleration due to gravity in m/sec^2
R=12742/2;// km

// Calculation
// (a)
r_max=R+h_2;// km
r_min=R+h_1;// km
a=(r_min+r_max)/2;// km
v_P=(R*10^3*sqrt(g/(a*10^3))*sqrt(r_max/r_min));// m/s
v_A=(R*10^3*sqrt(g/(a*10^3))*sqrt(r_min/r_max));// m/s
// (b)
r=R+h_c;// km
v_C=sqrt((2*g*(R*10^3)^2)*((1/r)-(1/(2*a)))*(1/10^3));// m/s
// (c)
tau=(2*%pi*((a*10^3)^(3/2)))/((R*10^3)*sqrt(g));// km
tau_h=tau/3600;// km
printf("\n(a)The necessary perigee velocity,v_P=%4.0f m/s (or) %5.0f km/h \n  The necessary apogee velocity,v_A=%4.0f m/s (or) %5.0f km/h \n(b)The velocity at point C,v_C=%4.0f m/s (or) %5.0f km/h \n(c)The period of the orbit,tau=%1.3f h",v_P,v_P*3.6,v_A,v_A*3.6,v_C,v_C*3.6,tau_h);
```

Chapter 4

Kinetics of Systems of Particles

Scilab code Exa 4.4 The velocity which fragment C has immediately after the explosion

```
// SAMPLE PROBLEM 4/4
clc;clear;funcprot(0);
// Given data
m=20;// kg
u_z=300;// m/s
g=9.81;// m/s^2
m_a=5;// kg
m_b=9;// kg
m_c=6;// kg
theta=45;// degree
s=4000;// m
x=3;// m
y=4;// m
r=5;// m
h_a=500;// m

// Calculation
t=(u_z*(y/r))/g;// The time required for the shell
    to reach P in s
h=u_z^2/(2*g);// The verticl rise in m
```

```
v_a=sqrt(2*g*h_a);// m/s
v_b=s/t;// m/s
v_c=[(m*u_z*(x/r))-(m_b*v_b*cosd(theta)),(m_b*v_b*sind(theta)),(m_a*v_a)]/6;// m/s
v_c=sqrt((v_c(1))^2+(v_c(2))^2+(v_c(3))^2);// m/s
printf("\nThe velocity which fragment C has immediately after the explosion ,v_C=%3.0f m/s",v_c);
```

Scilab code Exa 4.5 The kinetic energy T

```
// SAMPLE PROBLEM 4/5
clc;clear;funcprot(0);
// Given data
g=32.2;// The acceleration due to gravity in ft/sec^2
n_12=80;// rev/min
n_34=100;// rev/min
W_a=32.2;// lb
W_b=3.22;// lb
n=4;// Number of balls
vbar=4;// m/s
r_12=18/12;// ft
r_34=12/12;// ft

// Calculation
// (a)Kinetic energy
v_rel12=r_12*((2*%pi*n_12)/60);// ft/sec
v_rel34=r_34*((2*%pi*n_34)/60);// ft/sec
ke=(1/2)*((W_a/g)+(n*(W_b/g)))*(vbar)^2;// ft-lb
ke_r=(2*[(1/2)*(W_b/g)*v_rel12^2])+(2*[(1/2)*(W_b/g)*v_rel34^2]);// The rotational part of the kinetic energy in ft-lb
T=ke+ke_r;// The total kinetic energy in ft-lb
// (b)Linear momentum
```

```
G=((W_a/g)+(n*(W_b/g)))*vbar;// ft-lb-sec
// (c)Angular momentum about O.
H_O=(2*[(W_b/g)*r_12*v_rel12])-(2*[(W_b/g)*r_34*
    v_rel34]);// lb-sec
printf("\n(a)The kinetic energy,T=%2.0f ft-lb \n(b)
    The magnitude of the linear momentum,G=%1.1f lb-
    sec \n(c)The magnitude of the angular momentum
    about point O,H_O=%1.3f ft-lb-sec",T,G,H_O);
```

Chapter 5

Plane Kinematics of Rigid Bodies

Scilab code Exa 5.1 The time required for the flywheel to reduce its clockwise angular speed

```
// SAMPLE PROBLEM 5/1
clc;clear;funcprot(0);
// Given data
n_1=1800;// rev/min
t_0=0;// s
// alpha=4t;
n_2=900;// rev/min

// Calculation
// (a)
omega_1=(-2*%pi*n_1)/60;// rad/s
// omega=-(60*%pi)+2t^2
omega_2=(-2*%pi*n_2)/60;// rad/s
t=sqrt((omega_2-omega_1)/2);// s
// (b)
// The flywheel changes direction when its angular
    velocity is momentarily zero. Thus,
t_b=sqrt((0-omega_1)/2);// s
```

```
// (c)
t_0=0;// s
t_1=t_b;// s
theta_1=integrate('omega_1+(2*t^2)','t',t_0,t_1);// rad
N_1=abs(-theta_1/(2*%pi));// rev(clockwise)
t_1=t_b;// s
t_2=14;// s
theta_2=integrate('omega_1+(2*t^2)','t',t_1,t_2);// rad
N_2=theta_2/(2*%pi);// rev
N=N_1+N_2;// rev
printf("\n(a)The time required for the flywheel to reduce its clockwise angular speed,t=%1.2f s \n(b)The time required for the flywheel to reverse its direction of rotation,t=%1.2f s \n(c)The total number of revolutions,N=%3.0f rev",t,t_b,N);
```

Scilab code Exa 5.2 The angular velocity and angular acceleration of the pinion A

```
// SAMPLE PROBLEM 5/2
clc;clear;funcprot(0);
// Given data
v=3;// ft/sec
s=4;// ft
d_C=48;// inch
d_B=36;// inch
d_A=12;// inch
r_A=d_A/2;// inch
r_C=d_C/2;// inch
r_B=d_B/2;// inch

// Calculation
```

```
// (a)
a=v^2/(2*s);// ft/sec^2
a_t=a;// ft/sec^2
a_n=v^2/(r_C/12);// ft/sec^2
a_C=sqrt(a_n^2+a_t^2);// ft/sec^2
// (b)
omega_B=v/(r_C/12);// rad/sec
alpha_B=a_t/(r_C/12);// rad/sec^2
omega_A=(r_B/r_A)*omega_B;// rad/sec CW
alpha_A=(r_B/r_A)*alpha_B;// rad/sec^2 CW
printf("\n(a)The acceleration of point C on the cable in contact with the drum,a_C=%1.2f ft/sec^2 \n(b)The angular velocity and angular accelerationof the pinion A,omega_A=%1.1f rad/sec CW and alpha_A=%1.3f rad/sec^2 CW",a_C,omega_A,alpha_A);
```

Scilab code Exa 5.3 The vector expressions for the velocity and acceleration of point A

```
// SAMPLE PROBLEM 5/3
clc;clear;funcprot(0);
// Given data
alpha=4;// rad/s^2
omega=-2;// rad/s
x=0.4;// m
y=0.3;// m

// Calculation
// Using the right-hand rule gives
// omega=-2k rad/s and alpha=+4k rad/s^2
r=[x,y];// m
v=[-omega*r(2),omega*r(1)];// (i,j) (k*i=j)(k*j=-i) m/s
a_n=[-omega*v(2),omega*v(1)];// m/s^2
```

```
a_t=[-alpha*r(2),alpha*r(1)];// m/s^2
a=a_n+a_t;// m/s^2
printf("\nThe vector expression for the velocity,v=
    %0.1fi+(%0.1f)j m/s \nThe vector expression for
    the acceleration of point A,a=%2.1fi+%0.1fj m/s^2
    ",v(1),v(2),a(1),a(2));
v=norm(v);// m/s
a=norm(a);// m/s^2
```

Scilab code Exa 5.5 The velocity and acceleration of the load L

```
// SAMPLE PROBLEM 5/5
clc;funcprot(0);
// Given data
r_1=4;// inch
r_2=4;// inch
// Case(a)
// Pulley 1:
omega_1a=0;// rad/sec
omega_dot=0;// rad/sec
alpha_1a=omega_dot;
// Pulley 2:
omega_2a=2;// rad/sec
alpha_2a=-3;// rad/sec^2
// Case(b)
// Pulley 1:
omega_1b=1;// rad/sec
alpha_1b=4;// rad/sec^2
// Pulley 2:
omega_2b=2;// rad/sec
alpha_2b=-2;// rad/sec^2
ABbar=12;// inch
AObar=4;// inch

// Calculation
```

```
// Case (a)
v_D=r_2*omega_2a;// in/sec
a_D=r_2*alpha_2a;// in/sec
omega=v_D/ABbar;// rad/sec
alpha=a_D/ABbar;// in/sec^2
v_O=AObar*omega;// rad/sec (CCW)
a_O=AObar*alpha;// rad/sec^2 (CW)
printf("\n(a)omega=%0.3f rad/sec (CCW)\n    alpha=%1.0f rad/sec^2 (CW) \n    v_O=%1.3f in/sec \n    a_O=%1.0f in/sec^2",omega,alpha,v_O,a_O);
// Case (b)
v_C=r_1*omega_1b;// in/sec
v_D=r_2*omega_2b;// in/sec
a_C=r_1*alpha_1b;// in/sec^2
a_D=r_2*alpha_2b;// in/sec^2
omega=(v_D-v_C)/ABbar;// rad/sec (CCW)
alpha=(a_D-a_C)/ABbar;// rad/sec^2 (CW)
v_O=v_C+(AObar*omega);// in/sec
a_O=a_C+(AObar*alpha);// in/sec
printf("\n(b)omega=%0.3f rad/sec (CCW)\n    alpha=%1.0f rad/sec^2 (CW) \n    v_O=%1.3f in/sec \n    a_O=%1.0f in/sec^2",omega,alpha,v_O,a_O);
```

Scilab code Exa 5.6 The velocity and acceleration of the center of the roller B in the horizontal guide

```
// SAMPLE PROBLEM 5/6
clc;funcprot(0);
// Given data
v_A=0.3;// m/s
b=0.2;// m
theta=30;// degree

// Calculation
v_B=-v_A*tand(theta);// m/s
```

```
a_B=-((v_A^2)/b)*(secd(theta))^3;// m/s^2
omega=(v_A/b)*secd(theta);// rad/s
alpha=((v_A^2)/b^2)*(secd(theta))^2*tand(theta);//
   rad/s^2
printf("\nThe velocity of the center of the roller B
    in the horizontal guide,v_B=%1.4f m/s \nThe
   acceleration of the center of the roller B in the
    horizontal guide,a_B=%0.3f m/s^2 \nThe angular
   velocity of edge CB,omega=%1.3f rad/s \nThe
   angular acceleration of edge CB,alpha=%1.3f rad/
   sec^2",v_B,a_B,omega,alpha);
```

Scilab code Exa 5.7 The velocity of point A on the wheel

```
// SAMPLE PROBLEM 5/7
clc;funcprot(0);
// Given data
r=0.300;// m
v_O=3;// m/s
theta=30;// degree
r_0=0.200;// m
ACbar=0.436;// m
OCbar=0.300;// m

// Calculation
// Solution I (Scalar-Geometric)
omega=v_O/r;// rad/s
v_AO=r_0*omega;// m/s
v_A=sqrt(v_O^2+v_AO^2+(2*v_O*v_AO*cosd(theta)));// m
   /s
v_AC=(ACbar/OCbar)*v_O;// m/s
v_A=v_AC;// m/s
printf("\nThe velocity of point A on the wheel,v_A=
   %1.2f m/s",v_A);
// Solution II (Vector)
```

```
omega=[0,0,-omega];// rad/s
r_0=[(r_0*-cosd(theta)),(r_0*sind(theta)),0];// m
v_O=[v_O,0,0];// m/s
v_AO1=det([omega(2),omega(3);r_0(2),r_0(3)]);// m/s
v_AO2=-det([omega(1),omega(3);r_0(1),r_0(3)]);// m/s
v_AO3=det([omega(1),omega(2);r_0(1),r_0(2)]);// m/s
v_AO=[v_AO1,v_AO2,v_AO3];// m/s
v_A=v_O+v_AO;// m/s
printf("\nThe velocity of point A on the wheel,v_A=
    %1.0fi+%1.3fj m/s",v_A(1),v_A(2));
v_A=norm(v_A);// m/s
```

Scilab code Exa 5.8 The angular velocities of OA and AB

```
// SAMPLE PROBLEM 5/8
clc;funcprot(0);
// Given data
OCbar=0.250;// m
omega=2;// rad/s
OAbar=0.100;// m
OBbar=0.050;// m
ABbar=0.075;// m

// Calculation
// Solution I (Vector)
r_A=[0,0.100,0];// (i,j,k) m
r_B=[-0.75,0,0];// (i,j,k) m
r_AB=[-0.175,0.50,0];// (i,j,k) m
// omega_OA*r=(omega_CB*r_B)+(omega_AB*r_AB);
// omega_OA=omega_OA*k
// omega_CB=2k
// omega_AB=omega_ABk
// Matching coefficients of the respective i- and j-
    terms gives
omega_AB=-(25*6)/(25*7);// rad/s
```

```
omega_OA=(50*omega_AB)/100;// rad/s
printf("\n(I)The angular velocity of OA,omega_OA=%0
    .3f rad/s \n    The angular velocity of AB,
    omega_AB=%0.3f rad/s",omega_OA,omega_AB);
// Solution II (Scalar-Geometric)
r_A=0.100;// m
r_B=0.075;// m
v_B=r_B*omega;// m/s
tantheta=(OAbar-OBbar)/(OCbar-r_B);
// v_AB=v_B/ cos(theta);
// ABbar= (OCbar-r_AB)/ cos(theta);
v_A=v_B*tantheta;// m/s
omega_AB=(v_B)/(OCbar-r_B);// rad/s CW
omega_OA=v_A/OAbar;// rad/s CW
printf("\n(II)The angular velocity of OA,omega_OA=%0
    .3f rad/s \n     The angular velocity of AB,
    omega_AB=%0.3f rad/s",omega_OA,omega_AB);
```

Scilab code Exa 5.9 The velocity of point G on the connecting rod

```
// SAMPLE PROBLEM 5/9
clc;funcprot(0);
// Given data
n=1500;// rev/min
theta=60;// degree
r=5;// inch
d_AG=10;// The distance from A to G in inch
d_GB=4;// The distance from G to B in inch
d_AB=14;// The distance from A to B in inch

// Calculation
v_B=(r/12)*((2*%pi*n)/60);// ft/sec
// From the law of sines ,
beta=asind(r/(d_AB/sind(theta)));// degree
theta_3=30;// degree
```

```
theta_1=90-beta;// degree
theta_2=180-theta_3-theta_1;// degree
v_A=(v_B*sind(theta_2))/sind(theta_1);// ft/sec
v_AB=(v_B*sind(theta_3))/sind(theta_1);// ft/sec
ABbar=d_AB/12;// ft
omega_AB=v_AB/ABbar;// rad/sec
GBbar=d_GB/12;// ft
v_GB=(GBbar/ABbar)*v_AB;// ft/sec
// From velocity diagram
v_G=64.1;// ft/sec
printf("\nThe velocity of the piston A,v_A=%2.1f ft/
    sec \nThe velocity of point G on the connecting
    rod,v_G=%2.1f ft/sec \nThe angular velocity of
    the connecting rod,omega_AB=%2.1f rad/sec",v_A,
    v_G,omega_AB);
```

Scilab code Exa 5.10 The angular velocity of the slotted arm

```
// SAMPLE PROBLEM 5/10
clc;funcprot(0);
// Given data
v_B=0.8;// The velocity in m/s
theta=30;// degree
d_co=18;// The distance in inch

// Calculation
v_A=v_B*cosd(theta);// ft/sec
OAbar=(d_co/12)/(cosd(theta));// ft
omega=v_A/(OAbar);// rad/sec CCW
printf("\nThe angular velocity of the slotted arm,
    omega=%0.3f rad/sec CCW",omega);
```

Scilab code Exa 5.11 The velocity of point A for the position indicated

```
// SAMPLE PROBLEM 5/11
clc;funcprot(0);
// Given data
r=300/1000;// m
r_0=200/1000;// m
v_o=3;// m/s
OCbar=r;// m
theta=120;// degree

// Calculation
omega=v_o/OCbar;// rad/s
ACbar=sqrt(r^2+r_0^2-(2*r*r_0*cosd(theta)));// m
v_A=ACbar*omega;// m/s
printf("\nThe velocity of point A for the position
    indicated,v_A=%1.2f m/s",v_A);
```

Scilab code Exa 5.12 The velocity of A and the velocity of D and the angular velocity of link AB for the position shown

```
// SAMPLE PROBLEM 5/12
clc;funcprot(0);
// Given data
omega_OB=10;// rad/sec
theta=45;// degree
OBbar=(6*sqrt(2))/12;// ft
BCbar=(14*sqrt(2))/12;// ft
ACbar=14/12;// ft
CDbar=15.23/12;// ft

// Calculation
omega_BC=(OBbar*omega_OB)/BCbar;// rad/sec CCW
v_A=ACbar*omega_BC;// ft/sec
v_D=CDbar*omega_BC;// ft/sec
printf("\nThe velocity of A,v_A=%1.2f ft/sec \nThe
    velocity of D,v_D=%1.2f ft/sec \nThe angular
```

```
velocity of link AB,omega_AB=%1.2f rad/sec CCW",
v_A,v_D,omega_BC);
```

Scilab code Exa 5.14 The angular acceleration of links AB and OA for this position

```
// SAMPLE PROBLEM 5/14
clc;clear;funcprot(0);
// Given data
omega_CB=2;// rad/s
r_A=100;// mm
r_B=75;// mm
OCbar=250;// mm

// Calculation
omega_AB=-6/7;// rad/s
omega_OA=-3/7;// rad/s
// The acceleration equation is a_A=a_B+(a_A/B)_n+(a_A/B)_t;
// a_A=(alpha_OA*r_A)+(omega_OA*(omega_OA*r_A))
// a_A=(-100*alpha_OA)i-((100)*(3/7)^2)j mm/s^2
// a_B=(alpha_CB*r_B)+(omega_CB*(omega_CB*r_B)) mm/s^2
// a_B=300i mm/s^2
// (a_A/B)n=omega_AB*(omega_AB*r_AB)
// (a_A/B)n=(6/7)^2*(175i-50j) mm/s^2
// (a_A/B)t= alpha_AB*r_A/B
// (a_A/B)t=(-50*alpha_AB)i-(175*alpha_AB)j mm/s^2
// Equate separately the coefficients of the i-terms and the coefficients of the j-terms to give
function[X]=acceleration(y)
    X(1)=(-100*y(1))-(429-(50*y(2)));
    X(2)=(-18.37)-(-36.7-(175*y(2)));
endfunction
y=[0.1 1];
```

```
z=fsolve(y,acceleration);
alpha_AB=z(2);// mm/s^2
alpha_OA=z(1);// mm/s^2
printf("\nThe angular acceleration of link AB,
    alpha_AB=%0.4f rad/s^2 \nThe angular acceleration
     of link OA,alpha_OA=%1.2f rad/s^2",alpha_AB,
    alpha_OA);
```

Scilab code Exa 5.15 The acceleration of the piston A and the angular acceleration of the connecting rod AB

```
// SAMPLE PROBLEM 5/15
clc;funcprot(0);
// Given data
N=1500;// rev/min
theta_1=60;// degree
r=5/12;// ft
ABbar=14/12;// ft

// Calculation
omega=(2*%pi*N)/60;// rad/s
a_B=r*omega^2;// ft/sec^2
omega_AB=29.5;// rad/sec
a_AB_n=ABbar*omega_AB^2;
// If we adopt an algebraic solution using the
    geometry of the acceleration polygon, we first
    compute the angle between AB and the horizontal.
    With the law of sines, this angle becomes 18.02
    degree.
theta_2=18.02;// degree
function[X]=acceleration(y)
    X(1)=((a_B*cosd(theta_1))+(a_AB_n*cosd(theta_2))
        -(y(2)*sind(theta_2)))-y(1);
    X(2)=((a_B*sind(theta_1))-(a_AB_n*sind(theta_2))
        -(y(2)*cosd(theta_2)))-0;
```

```
endfunction
y=[1000 1000];
z=fsolve(y,acceleration)
a_AB_t=z(2);// ft/sec^2
a_A=z(1);// ft/sec^2
r=ABbar;// ft
alpha_AB=a_AB_t/r;// rad/sec^2
printf("\nThe acceleration of the piston A,a_A=%4.0f ft/sec^2 \nThe angular acceleration of the connecting rod AB,alpha_AB=%4.0f rad/sec^2",a_A,alpha_AB);
```

Scilab code Exa 5.16 The absolute velocity and acceleration of A for this position

```
// SAMPLE PROBLEM 5/16
clc;funcprot(0);
// Given data
omega=4;// rad/sec
omegadot=10;// rad/sec^2
r=6;// in
rdot=5;// in/sec
rdotdot=81;// in/sec^2

// Calculation
// Velocity
v_rel=rdot;// (k) in/sec
v_A=[v_rel,(omega*r)];// in/sec
printf("\nv_A=%1.0fi+%2.0fj in/sec",v_A(1),v_A(2));
v_A=norm(v_A);// in/sec
printf("\nv_A=%2.1f in/sec",v_A);
// Acceleration
// Assume O=omega*(omega*r);O_1=omegadot*r;O_2=(2*omega*v_rel);
O=-(omega*(omega*r));// in/sec^2
```

```
O_1=-omegadot*r;// in/sec^2
O_2=2*(omega)*(v_rel);// in/sec^2
a_rel=rdotdot;// in/sec^2
a_A=[(a_rel+O),(O_2+O_1)];// in/sec^2
printf("\na_A=%2.0fi+(%2.0f)j in/sec^2",a_A(1),a_A(2));
a_A=norm(a_A);// in/sec^2
printf("\na_A=%2.0f in/sec",a_A);
```

Scilab code Exa 5.17 The velocity of pin A and the velocity of A relative to the rotating slot in OD

```
// SAMPLE PROBLEM 5/17
clc;clear;funcprot(0);
// Given data
omega=2;// rad/sec
theta=45;// degree
OCbar=450;// mm
CAbar=225;// mm

// Calculation
// v_A=omega_CA*r_CA;
// v_A=(225/sqrt(2))omega_CA*(i-j)
OPbar=sqrt((OCbar-CAbar)^2+(CAbar)^2);// mm
r=OPbar;// mm
omega=omega;//(k) rad/s
O=omega*r;// mm/s
// Substitution into the relative-velocity equation gives
// (225/sqrt(2))omega_CA*(i-j)=(450*sqrt(2)j+xdoti)
// Equating separately the coefficients of the i and j terms yields
omega_CA=O/(225/sqrt(2));// mm/s
xdot=(225/sqrt(2))*omega_CA;// mm/s
v_rel=xdot;// mm/s
```

```
v_A=CAbar*abs(omega_CA);// mm/s
v_P=OPbar*omega;// mm/s
v_AP=abs(v_rel);// mm/s
omega_AC=v_A/CAbar;// rad/s
printf("\nThe actual angular velocity of CA,omega_CA=%1.0f rad/s \nThe velocity of A relative to the rotating slot in OD,xdot=v_rel=%3.2f mm/s \nThe velocity of pin A,v_A=%3.0f mm/s",omega_CA,xdot,v_A);
```

Scilab code Exa 5.18 The angular acceleration of AC and the acceleration of A relative to the rotating slot in arm OD

```
// SAMPLE PROBLEM 5/18
clc;clear;funcprot(0);
// Given data
omega=2;// rad/s
theta=45;// degree
OCbar=450;// mm
CAbar=225;// mm

// Calculation
// a_A=(omegadot*r)+(omega*(omega*r))+(2*omega*v_rel)+a_rel
// a_A=(omegadot_CA*r_CA)+omega_CA*(omega_CA*r_CA)
// a_A=[omegadot_CA*(225/sqrt(2))*(-i-j)]-[4k*(-4k*225/sqrt(2))*(-i-j)]
omega=2;// rad/s
r=CAbar*sqrt(2);// mm
omega_CA=-4;// rad/s
v_rel=(-OCbar*sqrt(2));// mm/s
// Assume O=omega*(omega*r);O_1=omegadot*r;O_2=(2*omega*v_rel);
O_1=0;// mm/s^2
O_2=omega*(omega*r);// mm/s^2
```

```
O_2=2*omega*v_rel;// mm/s^2
// a_rel=xdotdot;
// [(1/sqrt(2))*(225omegadot_CA+3600)i]+[(1/sqrt(2))*(-225omegadot_CA+3600)j] =(900*sqrt(2))i-(1800*sqrt(2))j+xdotdoti
omegadot_CA=(((-1800*sqrt(2))*sqrt(2))-3600)/-225;// rad/s^2
xdotdot=(((225*omegadot_CA)+3600)/sqrt(2))-(-900*sqrt(2));// mm/s^2
printf("\nThe angular acceleration of AC,omega_CA=%2.0f rad/s \nThe acceleration of A relative to the rotating slot in OD,xdotdot=%4.0f mm/s",omegadot_CA,xdotdot);
```

Scilab code Exa 5.19 The instantaneous velocity and acceleration

```
// SAMPLE PROBLEM 5/19
clc;clear;funcprot(0);
// Given data
v_B=150;// (i) m/s
v_A=100;// (i) m/s
rho=400;// m
r=-100;// m

// Calculation
omega=v_B/rho;// (k) rad/s
r_AB=r;// (j) m
v_rel=[v_A-(v_B+(-(omega*r)))];// (i) m/s
a_A=0;// m/s^2
a_B=(v_B(1))^2/rho;// m/s^2
omegadot=0;// rad/s
a_rel=a_A-[a_B+(omegadot*r)+(omega*-(omega*r))+(2*(omega*v_rel))];// m/s^2
printf("\nThe instantaneous velocity,v_rel=%2.1fi m/s \nThe instantaneous acceleration,a=%1.2fk m/s^2
```

```
    ",v_rel,a_rel);
v_AB=v_A-v_B;// (i) m/s
a_AB=a_A-a_B;// (j) m/s^2
```

Chapter 6

Plane Kinetics of Rigid Bodies

Scilab code Exa 6.1 The normal force under each pair of wheels

```
// SAMPLE PROBLEM 6/1
clc;funcprot(0);
// Given data
W=3220;// lb
v=44;// m/s (30 mi/hr)
s=200;// ft
mu=0.8;// The effective coefficient of friction
   between the tires and the road
g=32.2;// The acceleration due to gravity in ft/sec
   ^2
d_G=24;// inch
d_BG=60;// inch
d_GA=60;// inch

// Calculation
abar=v^2/(2*s);// ft/sec^2
theta=atand(1/10);// degree
W_h=W*cosd(theta);// lb
W_v=W*sind(theta);// lb
mabar=(W/g)*abar;// lb
// SigmaF_x = m*abar_x
```

```
F=mabar+W_v;// lb
function[X]=reaction(y)
    X(1)=(y(1)+y(2)-W)-0;
    X(2)=((d_GA*y(1))+(F*d_G)-(y(2)*d_BG))-0;
endfunction
y=[1000,1000];
z=fsolve(y,reaction);
N_1=z(1);// lb
N_2=z(2);// lb
FbyN_2=F/N_2;
printf("\nThe friction force under the rear driving
   wheels,F=%3.0f lb \nThe normal force under each
   pair of wheels,N_1=%4.0f lb & N_2=%4.0f lb",F,N_1
   ,N_2);
// Alternative solution
// SigmaM_A=m*abar*d
// SigmaM_A=m*abar*d
N_2=((mabar*d_G)+((d_GA*W_h)+(d_G*W_v)))/(d_BG+d_GA)
   ;// lb
// SigmaM_B=m*abar*d;
N_1=((W_h*d_BG)-(d_G*W_v)-(mabar*d_G))/(d_BG+d_GA);
   // lb
printf("\nALTERNATIVE SOLUTION:The normal force
   under each pair of wheels,N_1=%4.0f lb & N_2=%4.0
   f lb",N_1,N_2);
```

Scilab code Exa 6.2 The angular acceleration of the links

```
// SAMPLE PROBLEM 6/2
clc;clear;funcprot(0);
// Given data
m=150;// kg
M=5;// kN
theta=30;// degree
ACbar=1.5;// m
```

```
BDbar=1.5;// m
ABbar=1.8;// m
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
// SigmaM_C=0
A_t=M/ACbar;// kN
// SigmaF_t=m*abar_t
// alpha=14.81-6.54*cos(theta);
wsquare_30=(29.6*theta*%pi/180)-(13.08*sind(theta));// (rad/s)^2
alpha_30=14.81-(6.54*cosd(theta));// rad/s^2
A_n=(m/1000)*ACbar*wsquare_30;// kN
A_t=(m/1000)*BDbar*alpha_30;// kN
// SigmaM_A=m*abar*d
B=((A_n*(ABbar-0.6)*cosd(theta))+(A_t*0.6))/(ABbar*cosd(theta));// kN
printf("\nThe force in the link DB,B=%1.2f kN",B);
```

Scilab code Exa 6.3 The vertical acceleration of the block and the resultant force on the bearing at O

```
// SAMPLE PROBLEM 6/3
clc;funcprot(0);
// Given data
W_b=644;// lb
r_i=12;// inch
r_o=24;// inch
theta=45;// degree
P=400;// lb
k_o=18;// inch
W=322;// lb
g=32.2;// lb

// Calculation
```

```
// Solution 1
// I=k^2*m
Ibar=(k_o/12)^2*(W/g);// lb-ft-sec^2
function[X]=acceleration(y)
// SigmaM_G=Ibar*alpha
    X(1)=((P*(r_o/12))-(y(1)*(r_i/12)))-(Ibar*y(2));
// SigmaF_y=m*a_y
    X(2)=((y(1)-W_b))-((W_b/g)*y(3));
// a_t=r*a;
    X(3)=y(3)-((r_i/12)*y(2));
endfunction
y=[100 1 1];
z=fsolve(y,acceleration);
T=z(1);// lb
alpha=z(2);// rad/sec^2
a=z(3);// ft/sec^2
// SigmaF_x=0
O_x=P*cosd(theta);// lb
// SigmaF_y=0
O_y=W+T+(P*sind(theta));// lb
O=sqrt(O_x^2+O_y^2);// lb
printf("\nSolution I:T=%3.0f lb,alpha=%1.2f rad/sec^2,a=%1.2f ft/sec^2,O=%4.0f lb",T,alpha,a,O);
// Solution 2
function[Y]=acceleration(x)
// SigmaM_o=(Ibar*alpha)+(m*abar*d)
    Y(1)=((P*(r_o/12))-(W_b*(r_i/12)))-((Ibar*x(1))+((W_b/g)*x(2)*(r_i/12)));
// a_t=r*a;
    Y(2)=x(2)-((r_i/12)*x(1));
endfunction
x=[1 1];
m=fsolve(x,acceleration);
alpha=m(1);// rad/sec^2
a=m(2);// ft/sec^2
// SigmaF_y=Sigmam*(a_ybar)
O_y=(W+W_b+(P*sind(theta)))+(((W/g)*(0))+((W_b/g)*alpha));// lb
```

```
// SigmaF_x=Sigmam*(a_xbar)
O_x=P*sind(theta);// lb
```

Scilab code Exa 6.4 The total force supported by the bearing at the instant

```
// SAMPLE PROBLEM 6/4
clc;funcprot(0);
// Given data
m=7.5;// kg
rbar=250/1000;// m
k_o=295/1000;// m
theta_1=0;// degree
theta_2=60;// degree
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
// SigmaM_o=I_o*alpha;
// alpha=28.2*cos(theta);
wsquare=48.8;// (rad/s)^2
// SigmaF_n=m*rbar*omega^2;
O_n=(m*rbar*wsquare)+(m*g*sind(theta_2));// N
// SigmaF_t=m*rbar*alpha;
O_t=(m*g*cosd(theta_2))-(m*rbar*28.2*cosd(theta_2));
    // N
O=sqrt(O_n^2+O_t^2);// N
q=k_o^2/(rbar);// The distance in m
// SigmaM_Q=0
O_t=(m*g*cosd(theta_2)*(q-rbar))/q;// N
printf("\nThe total force supported by the bearing,O
    =%3.1f N \nO_t=%2.2f N",O,O_t);
```

Scilab code Exa 6.5 The angular acceleration of the hoop and the time t for the hoop

```
// SAMPLE PROBLEM 6/5
clc;funcprot(0);
// Given data
r=6/12;// ft
mu_s=0.15;// The coefficients of static friction
mu_k=0.12;// The coefficients of kinetic friction
theta=20;// degree
g=32.2;// The acceleration due to gravity in ft/sec^2
x=10;// ft

// Calculation
// SigmaF_x=m*abar_x-----> mg*sind(theta)-F=m*abar
// SigmaF_x=m*abar_y-----> N-mg*cosd(theta)=0
// SigmaM_G=Ibar*alpha----> F*r=m*r^2*alpha
abar=(g/2)*sind(theta);// ft/sec^2
// SigmaM_G=Ibar*alpha+m*abar*d------->mgr*sin(theta)=mr^2*(abar/r)+ m*abar*r
// From the above equations,we solve using the coefficients of mg
F=sind(theta)-(sind(theta))/2;// N
N=cosd(theta);// N
F_max=mu_s*N;// N
F=mu_k*N;// N
// SigmaF_x=m*abar_x
abar=(sind(theta)-F)*g;// ft/sec^2
alpha=(F*g)/r;// rad/sec^2
t=sqrt((2*x)/abar);// sec
printf("\nThe angular acceleration of the hoop,alpha=%1.2f ft/sec^2 \nThe time t for the hoop to move a distance of 10 ft down the incline,t=%1.3f sec",alpha,t);
```

Scilab code Exa 6.6 The tension T in the cable and the friction force F exerted by the horizontal surface on the spool

```
// SAMPLE PROBLEM 6/6
clc;funcprot(0);
// Given data
alpha_0=3;// rad/s^2
m=70;// kg
k=0.250;// The radius of gyration in m
mu_s=0.25;// The coefficient of static friction
g=9.81;// The acceleration due to gravity in m/s^2
DCbar=0.30;// m
r_A=0.250;// m
r_Bi=0.150;// m
r_Bo=0.450;// m

// Calculation
a_t=r_A*alpha_0;// m/s^2
alpha=a_t/DCbar;// rad/s^2
abar=r_Bo*alpha;// m/s^2
function[X]=force(y)
    // SigmaF_x=m*abar_x
    X(1)=(y(1)-y(2))-(m*-abar);
    N=(m*g);// N
    // SigmaM_G=Ibar*alpha
    X(2)=((r_Bo*y(1))-(r_Bi*y(2)))-(m*k^2*alpha);
endfunction
y=[10 100];
z=fsolve(y,force);
F=z(1);// N
T=z(2);// N
printf("\nThe tension in the cable,T=%3.1f N \nThe
   friction force exerted by the horizontal surface
   on the spool,F=%2.1f N",T,F);
```

```
N=(m*g);// N
F_max=mu_s*N;// N
// If the coefficient of static friction had been 0.1
mu_s=0.1;// The coefficient of static friction
F=mu_s*(m*g);// N
// SigmaM_C=Ibar*alpha + m*abar*r
T=((m*(r_A^2)*alpha)+(m*abar*r_Bo))/DCbar;// N
printf("\nThe tension in the cable,T=%3.1f N",T);
```

Scilab code Exa 6.7 The resulting angular acceleration of the bar and the forces on the small end rollers at A and B

```
// SAMPLE PROBLEM 6/7
clc;funcprot(0);
// Given data
W=60;// lb
theta=30;// degree
F=30;// lb
BGbar=2;// ft
AGbar=2;// ft
l=4;// ft
g=32.2;// The acceleration due to gravity in ft/sec^2

// Calculation
// abar_x=abar*cos(theta)=1.732*alpha;
// abar_y=abar*sin(theta)=1.0*alpha;
function[X]=force(y)
    // SigmaM_G=Ibar*alpha;
    X(1)=((F*(2*cosd(theta)))-(y(1)*(AGbar*sind(theta)))+(y(2)*(BGbar*cosd(theta))))-((1/12)*(W/g)*l^2*y(3));
    // SigmaF_x=m*abar_x;
    X(2)=(F-y(2))-((W/g)*(2*cosd(theta)*y(3)));
```

```
    // SigmaF_y=m*abar_y;
    X(3)=(y(1)-W)-((W/g)*2*sind(theta)*y(3));
endfunction
y=[10 10 1];
z=fsolve(y,force);
A=z(1);// lb
B=z(2);// lb
alpha=z(3);// rad/sec^2
printf("\nThe forces on the small end rollers ,A=%2
   .1f lb and B=%2.2f lb \nThe resulting angular
   acceleration of the bar,alpha=%1.2f rad/sec^2",A,
   B,alpha);
// Alternative solution
// SigmaM_C=(Ibar*alpha)+(Sigma m*abar*d)
alpha=((F*(l*cosd(theta)))-(W*2*sind(theta)))
   /((((1/12)*(W/g)*l^2)+((W/g)*1.732*2*cosd(theta))
   +((W/g)*1*2*sind(theta)));// rad/sec^2
// SigmaF_x=m*abar_x;
abar_y=2*alpha*sind(theta);// ft
A=((W/g)*abar_y)+W;// lb
// SigmaF_x=m*abar_x;
abar_x=2*alpha*cosd(theta);// ft
B=F-((W/g)*abar_x);// lb
printf("\nAlternative solution: \nThe forces on the
   small end rollers ,A=%2.1f lb and B=%2.2f lb \
   nThe resulting angular acceleration of the bar,
   alpha=%1.2f rad/sec^2",A,B,alpha);
```

Scilab code Exa 6.9 The power input

```
// SAMPLE PROBLEM 6/9
clc;funcprot(0);
// Given data
F=100;// N
m=40;// kg
```

```
k=0.150;// m
theta=15;// degree
r_i=0.100;// m
r_o=0.200;// m
l=3;// The distance in m
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
W=m*g;// N
l=(r_o+r_i)/r_i;// m
U_12=(F*((r_o+r_i)/r_i)*l)-((W*sind(theta)*l));// J
T_1=0;// J
// T_2=((1/2)*m*vbar^2)+((1/2)*Ibar*omega^2);
// The work-energy equation gives
omega=sqrt((T_1+U_12)/(((1/2)*m*(r_i)^2)+((1/2)*m*k
    ^2)));// rad/s
// Alternatively, the kinetic energy of the wheel
    may be written
// T=(1/2)*I_C*omega^2
P_100=F*(r_o+r_i)*omega;// W
printf("The power input,P=%3.0f W",P_100);
```

Scilab code Exa 6.10 The angular velocity of the bar

```
// SAMPLE PROBLEM 6/10
clc;funcprot(0);
// Given data
l=4;// ft
W=40;// The weight of the slender bar in N
theta=30;// degree
k=30;// The stiffness of the spring in lb/in
ABbar=24;// inch
BDbar=24;// inch
h=-2;// inch
g=32.2;// The acceleration due to gravity in ft/sec
```

```
^2


// Calculation
// (a)
// T=[[(1/2)*m*v^2]+((1/2)*I_G*omega^2)];
// T=1.449*omega^2;
T_1=0;// ft-lb
U_12=0;// ft-lb
V_1=0;// ft-lb
V_2=W*((2*cosd(theta))-2);// ft-lb
// We now substitute into the energy equation and obtain
omega=sqrt(((T_1+V_1+U_12)-(V_2))/1.449);// rad/sec
// (b)
x=ABbar-18;// ft
V_1=0;// ft-lb
V_3=(1/2)*k*(x^2)/12;// ft-lb
// T=(1/2)*I_A*omega^2;
// T_3=0.828*v_B^2;
U_13=0;// ft-lb
// The final gravitational potential energy is
V_3p=W*h;// ft-lb
v_B=sqrt(((T_1+V_1+U_13)-(V_3+V_3p))/0.828);// ft-lb
printf("\n(a)The angular velocity of the bar,omega=%1.2f rad/sec \n(b)The velocity with which B strikes the horizontal surface,v_B=%1.2f ft/sec",omega,v_B);
```

Scilab code Exa 6.11 The maximum deformation x of the spring

```
// SAMPLE PROBLEM 6/11
clc;funcprot(0);
// Given data
m=30;// kg
```

```
k=0.100;// m
m_OB=10;// kg
m_c=7;// kg
K=30;// kN/m
theta=45;// degree
l=0.375;// m
g=9.81;// m/s^2

// Calculation
// (a)
// T_2=[2*((1/2)*I_G*omega^2]+[(1/2)*m*v^2];
// T_2= 6.83*v_B^2;
T_1=0;// J
l_b=l/sqrt(2);// m
V_1=(2*m_OB*g*(l_b/2))+(m_c*g*l_b);// J
V_2=0;// J
U_12=0;// J
v_B=sqrt(((T_1+V_1+U_12)-(V_2))/6.83);// m/s
// (b)
T_3=0;// J
U_13=0;// J
function[X]=deformation(y)
    X(1)=(T_1+V_1+U_13)-(T_3+((-2*m_OB*g*(y(1)/2))-(
        m_c*g*y(1))+((1/2)*K*10^3*y(1)^2)));
endfunction
y=[10];
z=fsolve(y,deformation);
x=z(1)*1000;// mm
printf("\n(a)The velocity of the collar as it first
   strikes the spring,v_B=%1.2f m/s \n(b)The maximum
    deformation of the spring,x=%2.1f mm",v_B,x);
```

Scilab code Exa 6.12 The acceleration a of rack A

```
// SAMPLE PROBLEM 6/12
```

```
clc;funcprot(0);
// Given data
m_A=3;// kg
m=2;// kg
k=0.060;// The radius of gyration in m
k=1.2;// The spring stiffness in kN/m
F=80;// N
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
// dT_rack=3a dx
// dT_gear=0.781a dx
// dV_rack=29.4 dx
// dV_gear=9.81 dx
// dV_spring=24 dx
// Canceling dx and solving for a give
a=(80-(29.4+9.81+24))/(3+0.781);
printf("\nThe acceleration of rack A,a=%1.2f m/s^2",
   a);
```

Scilab code Exa 6.14 The angular velocity of the wheel

```
// SAMPLE PROBLEM 6/14
clc;funcprot(0);
// Given data
// P=1.5*t;
r_i=9/12;// ft
r_o=18/12;// ft
t_1=0;// s
t_2=10;// s
k=10/12;// ft
W=120;// lb
g=32.2;// The acceleration due to gravity in ft/sec
   ^2
v_1=-3;// ft/sec
```

```

// Calculation
function[X]=velocity(y)
    X(1)=(((W/g)*v_1)+integrate('((1.5*t)-y(2))','t',t_1,t_2))-((W/g)*(r_o*y(1)));
    X(2)=(((W/g)*(k)^2*(v_1/r_o))+integrate('((r_o*y(2))-(r_i*(1.5*t)))','t',t_1,t_2))-((W/g)*(k^2*y(1)));
endfunction;
y=[1 10];
z=fsolve(y,velocity);
omega_2=z(1);// rad/sec clockwise
printf("\nThe angular velocity of the wheel,omega_2=%1.2f rad/sec",omega_2);
```

Scilab code Exa 6.15 The tension T in the cable at O during the interval

```
// SAMPLE PROBLEM 6/15
clc;funcprot(0);
// Given data
m_E=30;// kg
m_D=40;// kg
v_1=1.2;// m/s
t_1=0;// s
t_2=5;// s
F=380;// N
d=375/1000;// m
k_o=250/1000;// m
g=9.81;// m/s^2

// Calculation
// [H_O1+(integral(t_2 to t_2))SigmaM_Odt=H_O2]
// Integrating we get
M=((((F*0.750)*t_2)-(((m_E+m_D)*g*d)*t_2))-(((F*0.750)*t_1)-(((m_E+m_D)*g*d)*t_1)));// N.m.s
```

```
Ibar=(m_E)*k_o^2;// kg-m^2
omega_1=v_1/d;//rad/sec
H_O1=-((m_E+m_D)*v_1*d)-(Ibar*(v_1/d));// N.m.s
// H_O2=-(m_E+m_D*v_2*d)-(Ibar*(v_2/d));
// H_O2=11.72*omega_2;
// Substituting into the momentum equation gives
omega_2=(H_O1+M)/11.72;// N.m.s
// [G_1+(integral(t_2 to t_2))SigmaFdt=G_2]
m=m_E+m_D;// kg
G_1=m*-(v_1);// (kg.m/s)
G_2=m*(d*omega_2);// (kg.m/s)
// Integrating
// SigmaF=[T*(t_2)+(F*t_2)-(m*g*t_2)]-[T*(t_1)+(F*t_1)-(m*g*t_1)];
T=((G_2-G_1)-(((F*t_2)-(m*g*t_2))-((F*t_1)-(m*g*t_1))))/(t_2-t_1);// N
printf("\nThe angular velocity,omega_2=%1.2f rad/s counter clockwise \nThe tension in the cable,T=%3.0f N",omega_2,T);
```

Chapter 7

Introduction to Three Dimensional Dynamics of Rigid Bodies

Scilab code Exa 7.1 The angular velocity of OA

```
// SAMPLE PROBLEM 7/1
clc;funcprot(0);
// Given data
L=0.8;// m
N=60;// rev/min
betadot=4;// rad/s
beta=30;// degree

// Solution
// (a)
omega_x=betadot;// (i) rad/s
omega_z=(2*%pi*N/60);// (k) rad/s
omega=[omega_x,0,omega_z];// (i,j,k) rad/s
printf("\n(a)The angular velocity of OA,omega=%1.0fi+%1.2fk rad/s",omega(1),omega(3));
// (b)
omegadot_z=0;// (k) rad/s
```

```
omegadot_x=omega_z*omega_x;// (i) rad/s
alpha=omegadot_x+omegadot_z;// (j) rad/s^2
alpha=[0,alpha,0];// (i,j,k) rad/s^2
printf("\n(b)The angular acceleration of OA, alpha=%2.1fj rad/s^2",alpha(2));
// (c)
r=[0,0.693,0.4];// m
// v=omega*r;
v_1=det([omega(2),omega(3);r(2),r(3)]);// m/s
v_2=-det([omega(1),omega(3);r(1),r(3)]);// m/s
v_3=det([omega(1),omega(2);r(1),r(2)]);// m/s
v=[v_1,v_2,v_3];// m/s
printf("\n(c)The velocity of point A, v=%1.2fi+(%1.2f)j+%1.2fk m/s",v(1),v(2),v(3));
// (d)
a_1=det([alpha(2),alpha(3);r(2),r(3)])+det([omega(2),omega(3);v(2),v(3)]);// m/s^2
a_2=-det([alpha(1),alpha(3);r(1),r(3)])+(-det([omega(1),omega(3);v(1),v(3)]));// m/s^2
a_3=det([alpha(1),alpha(2);r(1),r(2)])+det([omega(1),omega(2);v(1),v(2)]);// m/s^2
a=[a_1,a_2,a_3];// m/s^2
printf("\n(d)The acceleration of point A, v=%2.1fi+(%2.1f)j+(%1.2f)k m/s^2",a(1),a(2),a(3));
```

Scilab code Exa 7.2 The angular velocity and angular acceleration of the disk

```
// SAMPLE PROBLEM 7/2
clc;funcprot(0);
// Given data
N_0=120;// rev/min
N=60;// rev/min
gamma=30;// degree
OCbar=10;// inch
```

```
CAbar=5;// inch
theta=30;// degree

// Calculation
// (a)
omega_0=(2*%pi*N_0)/60;// rad/sec
omega_1=(2*%pi*N)/60;// rad/sec
omega=[0,(omega_1*cosd(gamma)),(omega_0+(omega_1*sind(theta)))];// rad/sec
printf("\n(a)The angular velocity ,omega=%1.2fj+%2.2fk rad/s",omega(2),omega(3));
alpha=[(omega_1*omega_0*cosd(theta)),0,0];// rad/sec^2
printf("\n(b)The angular acceleration ,alpha=%2.1fi rad/s^2",alpha(1));
r=[0,5,10];// inch
// (c)
// v=omega*r;
v_1=det([omega(2),omega(3);r(2),r(3)]);// in/sec
v_2=-det([omega(1),omega(3);r(1),r(3)]);// in/sec
v_3=det([omega(1),omega(2);r(1),r(2)]);// in/sec
v=[v_1,v_2,v_3];// in/sec
printf("\n(c)The velocity of point A,v=%2.1fi+(%1.0f)j+%1.fk in/sec",v(1),v(2),v(3));
// a=(alpha*r)+(omega*v)
a_1=det([alpha(2),alpha(3);r(2),r(3)])+det([omega(2),omega(3);v(2),v(3)]);// in/sec^2
a_2=-det([alpha(1),alpha(3);r(1),r(3)])+(-det([omega(1),omega(3);v(1),v(3)]));// in/sec^2
a_3=det([alpha(1),alpha(2);r(1),r(2)])+det([omega(1),omega(2);v(1),v(2)]);// in/sec^2
a=[a_1,a_2,a_3];// in/sec^2
printf("\n   The acceleration of point A,a=%1.0fi+(%1.0f)j+%3.0fk in/sec^2",a(1),a(2),a(3));
```

Scilab code Exa 7.3 The angular velocity of crank DA and the angular velocity of link AB

```
// SAMPLE PROBLEM 7/3
clc;funcprot(0);
// Given data
omega_1=6;// rad/s
r_x=50;// mm
r_y=100;// mm
r_z=100;// mm


// Calculation
// v_A=r_x*omega_2;
v_B=r_y*omega_1;// (i) mm/s
// v_A=v_B+(omega_n*r_A/B);
// Expanding the determinant and equating the
   coefficients of the i, j, k terms give
function[X]=velocity(y)
    X(1)=-6-(y(2)-y(3));
    X(2)=y(4)-((-2*y(1))+y(3));
    X(3)=0-((2*y(1))-y(2));
    X(4)=((r_x*y(1))+(r_y*y(2))+(r_z*y(3)));
endfunction
y=[1 1 1 1];
z=fsolve(y,velocity);
omega_nx=z(1);// rad/s
omega_ny=z(2);// rad/s
omega_nz=z(3);// rad/s
omega_2=z(4);// rad/s
omega_n=[omega_nx,omega_ny,omega_nz];// rad/s
omega_n=norm(omega_n);// rad/s
printf("\nThe angular velocity of crank DA,omega_2=
   %1.0f rad/s \nThe angular velocity of link AB,
   omega_n=%1.3f rad/s",omega_2,omega_n);
```

Scilab code Exa 7.4 The angular acceleration of link AB

```
// SAMPLE PROBLEM 7/4
clc;funcprot(0);
// Given data
// From sample problem 7/3
omega_1=6;// rad/s
omega_2=6;// rad/s
r_x=50;// mm
r_y=100;// mm
r_z=100;// mm
omega_n=2*sqrt(5);// rad/s

// Calculation
r_AB=[r_x,r_y,r_z];// mm
// a_A=[r_x*omega_2^2]i+[r_x*omegadot]j;
// a_B=[r_y*omega_1^2]k+[0]i;
omegadot=(omega_n)^2*(r_AB);// rad/s^2
// omegadot*r_A/B=(100*omegadot_ny-100*omegadot_nz)i+(50*omegadot_nz-100*omegadot_nx)j+(100*omegadot_nx-50omegadot_ny)k
function[X]=velocity(y)
    X(1)=28-(y(2)-y(3));
    X(2)=(y(4)+40)-((-2*y(1))+y(3));
    X(3)=-32-((2*y(1))-y(2));
    X(4)=((2*y(1))+(4*y(2))+(4*y(3)));
endfunction
y=[1 10 10 10];
z=fsolve(y,velocity);
omegadot_nx=z(1);// rad/s^2
omegadot_ny=z(2);// rad/s^2
omegadot_nz=z(3);// rad/s^2
omegadot_2=z(4);// rad/s^2
omegadot_n=[omegadot_nx,omegadot_ny,omegadot_nz];//
```

```
    rad/s^2
omegadot_n=norm(omegadot_n);// rad/s^2
printf("\nThe angular acceleration of crank AD,
    omegadot_2=%2.0f rad/s \nThe angular acceleration
     of link AB,omegadot_n=%2.2f rad/s",omegadot_2,
    omegadot_n);
```

Scilab code Exa 7.5 The velocity and acceleration of point A

```
// SAMPLE Pr_BOBLEM 7/5
clc;funcprot(0);
// Given data
omega=3;// rad/s
p=8;// rad/s
gamma=30;// degree
y=0.300;// m
z=0.120;// m

// Calculation
// Velocity
omega=[0,0,3];// rad/s
r_B=[0,0.350,0];// m
v_B1=det([omega(2),omega(3);r_B(2),r_B(3)]);// m/s
v_B2=-det([omega(1),omega(3);r_B(1),r_B(3)]);// m/s
v_B3=det([omega(1),omega(2);r_B(1),r_B(2)]);// m/s
v_B=[v_B1,v_B2,v_B3];// m/s
// Note that k*i=J=jcos(gamma)-ksin(gamma),K*j=-i*
    cos(gamma) and K*k=i*sin(gamma)
r_AB=[0,y,z];// m
// omega*r_AB=3K*(yj+zk);
omegaintor_AB=(-(omega(3)*(y*cosd(gamma))))+(omega
    (3)*(z*sind(gamma)));// m/s
p=[0,8,0];// rad/s
v_rel1=det([p(2),p(3);r_AB(2),r_AB(3)]);// m/s
v_rel2=-det([p(1),p(3);r_AB(1),r_AB(3)]);// m/s
```

```
v_rel3=det([p(1),p(2);r_AB(1),r_AB(2)]);// m/s
v_rel=[v_rel1,v_rel2,v_rel3];// m/s
v_A=v_B(1)+omegaintor_AB+v_rel(1);// m/s
printf("\nThe velocity of point A,v_A=%0.4fi m/s",v_A);
// Acceleration
a_B1=det([omega(2),omega(3);v_B(2),v_B(3)]);// m/s^2
a_B2=-det([omega(1),omega(3);v_B(1),v_B(3)]);// m/s^2
a_B3=det([omega(1),omega(2);v_B(1),v_B(2)]);// m/s^2
a_B=[a_B1,a_B2,a_B3];// m/s^2
a_B=[0,((a_B(2)*(cosd(gamma)))),-(a_B(2)*(sind(gamma)))];// m/s^2
omegadot=0;// m/s^2
// Assume O=omega*(omega*r_A/B)
O=[0,((omega(3)*omegaintor_AB*(cosd(gamma)))),-omega(3)*(omegaintor_AB*(sind(gamma)))];// m/s^2
// Assume O_1=2*omega*v_rel
O_1=[0,((2*omega(3)*v_rel(1)*(cosd(gamma)))),-2*omega(3)*(v_rel(1)*(sind(gamma)))];// m/s^2
a_rel1=det([p(2),p(3);v_rel(2),v_rel(3)]);// m/s^2
a_rel2=-det([p(1),p(3);v_rel(1),v_rel(3)]);// m/s^2
a_rel3=det([p(1),p(2);v_rel(1),v_rel(2)]);// m/s^2
a_rel=[a_rel1,a_rel2,a_rel3];// m/s^2
a_A=[(a_B(1)+(omegadot*r_AB(1))+O(1)+O_1(1)+a_rel1),(a_B(2)+(omegadot*r_AB(2))+O(2)+O_1(2)+a_rel2),(a_B(3)+(omegadot*r_AB(3))+O(3)+O_1(3)+a_rel3)];// m/s^2
a_A=norm(a_A);// m/s^2
printf("\nThe acceleration of point A,a_A=%1.2f m/s",a_A);
// Angular Acceleration
// Note that k*i=J=jcos(gamma)-ksin(gamma),K*j=-i*cos(gamma) and K*k=i*sin(gamma)
omega=[3,8];// rad/s (K,j)(k*j=-i*cos(gamma))
alpha=[0+(-omega(1)*omega(2)*cosd(gamma))];// (i) rad/s^2
printf("\nThe angular acceleration of the disk,alpha
```

```
=%2.1fi rad/s^2",alpha);
```

Scilab code Exa 7.6 The angular momentum H of the plate about point O

```
// SAMPLE PROBLEM 7/6
clc;funcprot(0);
// Given data
m=70;// The mass of bent plate in kg
omega=30;// rad/s
x_A=0.125;// m
y_A=0.100;// m
x_B=0.075;// m
y_B=.150;// m
d_x=0.0375;// m
d_y=0.125;// m
d_z=0.075;// m

// Calculation
// Part A
m_A=x_A*y_A*m;// kg
m_B=x_B*y_B*m;// kg
I_xxA=((m_A/12)*(y_A^2+x_A^2))+(m_A*((x_A/2)^2+(y_A/2)^2));// kg.m^2
I_yyA=(m_A/3)*(y_A)^2;// kg.m^2
I_zzA=(m_A/3)*(x_A)^2;// kg.m^2
I_xyA=0;// kg.m^2
I_xzA=0;// kg.m^2
I_yzA=0+(m_A*(x_A/2)*(y_A/2));// kg.m^2
// Part B
I_xxB=((m_B/12)*(y_B^2))+((m_B)*(d_y^2+d_z^2));// kg.m^2
I_yyB=((m_B/12)*(x_B^2+y_B^2))+(m_B*(d_x^2+d_z^2));// kg.m^2
I_zzB=((m_B/12)*(x_B^2))+(m_B*((x_A)^2+(d_x^2)));//
```

```
kg.m^2
I_xyB=0+(m_B*d_x*d_y);// kg.m^2
I_xzB=0+(m_B*d_x*d_z);// kg.m^2
I_yzB=0+(m_B*d_y*d_z);// kg.m^2
I_xx=I_xxA+I_xxB;// kg.m^2
I_yy=I_yyA+I_yyB;// kg.m^2
I_zz=I_zzA+I_zzB;// kg.m^2
I_xy=I_xyA+I_xyB;// kg.m^2
I_xz=I_xzA+I_xzB;// kg.m^2
I_yz=I_yzA+I_yzB;// kg.m^2
// (a)
H_o=[-(omega*I_xz),-(omega*I_yz),(omega*I_zz)];// The angular momentum of the body in N.m.s
// (b)
T=(1/2)*(omega)*[H_o(3)];//(k.i=0,k.j=0,k.k=1) The kinetic energy in J
printf("\n(a)The angular momentum H of the plate about point O,H_O=%0.4fi+(%0.4f)j+%0.4fk \n(b)The kinetic energy of the plate,T=%1.2f J",H_o(1),H_o(2),H_o(3),T);
```

Scilab code Exa 7.8 The vertical components of the bearing reactions at A and B

```
// SAMPLE PROBLEM 7/8
clc;funcprot(0);
// Given data
m=1000;// The mass of turbine rotor in kg
k=0.200;// m
N=500;// rev/min
rho=400;// The radius of gyration in m
v=25*0.514;// m/s
d_AG=0.6;// m
d_GB=0.9;// m
d_AB=d_AG+d_GB;// m
```

```
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
// The moment principle from statics easily gives
W=m*g;// N
R_1=(m*g)*d_AG;// N
R_2=W-R_1;// N
omega=(v/rho);// rad/s
I=m*k^2;// kg-m^2
deltaR=(I*omega*((2*%pi*N)/60))/d_AB;
R_A=R_1-deltaR;// N
R_B=R_2+deltaR;// N
printf("\nThe vertical components of the bearing
    reactions at A and B,R_A=%4.0f N and R_B=%4.0f N"
    ,R_A,R_B);
// The answer provided in the textbook is wrong
```

Scilab code Exa 7.9 The number n of complete cycles of precession

```
// SAMPLE PROBLEM 7/9
clc;funcprot(0);
// Given data
t=4;// s
theta=20;// degree
p=(2*%pi)/4;// rad/s

// Calculation
// (a)
// I_zz=(56/3)*mr^2;
// I_xx=(32/3)*mr^2;
// By using coefficient of I_xx and I_zz
I=56/3;// The moment of inertia
I_0=32/3;// The moment of inertia
costheta=1;// radian
n=I/((I_0-I)*costheta);// The ratio of angular rates
```

```
// (b)
tau=((2*%pi)/p)*abs(((I_0-I)/I)*cosd(theta));// s
beta=atand((I/I_0)*tand(theta));// degree
printf("\n(a)The number of complete cycles,n=%1.2f \n    The minus sign indicates retrograde precession where, in the present case,and p are essentially of opposite sense. Thus, the station will make seven wobbles for every three revolutions. \n(b)The period of precession,tau=%1.3f s",n,tau);
```

Chapter 8

Vibration and Time Response

Scilab code Exa 8.1 The system period

```
// SAMPLE PROBLEM 8/1
clc;funcprot(0);
// Given data
W=25;// The weight of the body in lb
k=160;// lb/ft
v=2;// The downward velocity in  ft/sec
g=32.2;// The acceleration due to gravity in ft/sec
    ^2

// Calculation
// (a)
delta_st=W/k;// The static spring deflection in ft
delta_st=delta_st*12;// in
// (b)
omega_n=sqrt(k/(W/g));// The natural frequency of
    the system in rad/sec
f_n=omega_n*(1/(2*%pi));// The natural frequency of
    the system in cycles/sec
// (c)
tau=1/f_n;// The system period in sec
printf("\n(a)The static spring deflection ,delta_st=
```

```
%0.4f ft (or)%1.3f in \n(b)The natural frequency of the system,omega_n=%2.2f rad/sec \n   The natural frequency of the system,f_n=%0.3f sec \n(c)The system period,tau=%0.3f sec",delta_st/12,delta_st,omega_n,f_n,tau);
```

Scilab code Exa 8.2 The displacement of the body

```
// SAMPLE PROBLEM 8/2
clc;funcprot(0);
// Given data
m=8;// kg
s=0.2;// m
t_1=0;// s
t_2=2;// s
c=20;// N.s/m
k=32;// N/m

// Calculation
omega_n=sqrt(k/m);// rad/s
eta=c/(2*m*omega_n);// The damping ratio
omega_d=omega_n*(sqrt(1-eta^2));// The damped natural frequency in rad/s
x_2=0.256*(exp((-1.25*t_2)))*(sin((1.561*t_2)+0.896));// m
printf("\nThe displacement in meters, x_2=%0.5f m",x_2);
```

Scilab code Exa 8.4 The amplitude of the steady state motion of the instrument

```
// SAMPLE PROBLEM 8/4
clc;funcprot(0);
```

```
// Given data
m=50;// kg
n=4;// Number of springs
// x_B=0.002cos50t
b=0.002;// m
omega=50;// rad/s
k=7500;// The stiffness of the spring in N/m

// Calculation
omega_n=sqrt((n*k)/m);// The resonant frequency in rad/s
X=b/(1-(omega/omega_n)^2);// m
printf("\nThe amplitude of the steady-state motion of the instrument,X=%1.2e m (or) %0.3f mm",X,X*10^3);
```

Scilab code Exa 8.6 The steady state displacement as a function of time and the maximum force transmitted to the base

```
// SAMPLE PROBLEM 8/6
clc;funcprot(0);
// Given data
W=100;// The weight of the piston in lb
k=200;// The spring modulus in lb/in
c=85;// The damping coefficient in lb-sec/ft
a=80;// The top surface area in in^2
omega=30;// rad/s
g=32.2;// The acceleration due to gravity in ft/sec^2
p=0.625;// lb/in^2

// Calculation
omega_n=sqrt((k*12)/(W/g));// The natural frequency of the system in rad/sec
eta=c/(2*(W/g)*omega_n);// The damping ratio
```

```
F_0=p*a;// lb
X=(F_0/(k*12))/((1-(omega/omega_n)^2)^2+(2*eta*omega
    /omega_n)^2)^(1/2);// The steady-state amplitude
    in ft
phi=atan((2*eta*omega/omega_n)/(1-(omega/omega_n)^2)
    );// The phase angle in rad
// x_p=Xsin(omega*t-phi);
F_trmax=X*sqrt((k*12)^2+(c^2*omega^2));// The
    maximum force transmitted to the base in lb
printf("\nThe steady-state displacement as a
    function of time,x_p=%0.5fsin(%2.0ft-(%1.3f))ft \
    nThe maximum force transmitted to the base,(F_tr)
    _max=%2.1f lb",X,omega,phi,F_trmax);
```

Scilab code Exa 8.7 The period for small oscillations about the pivot

```
// SAMPLE PROBLEM 8/7
clc;funcprot(0);
// Given data
rbar=0.9;// m
k_o=0.95;// The radius of gyration in m
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
tau=2*%pi*sqrt(k_o^2/(g*rbar));// The period for
    small oscillations about the pivot in s
printf("\nThe period for small oscillations about
    the pivot,tau=%1.2f s",tau);
```

Scilab code Exa 8.9 The period of the damped system

```
// SAMPLE PROBLEM 8/9
clc;funcprot(0);
```

```
// Given data
m=50;// The mass of the cylinder in kg
r=0.5;// The cylinder radius in m
k=75;// The spring constant in N/m
c=10;// The damping coefficient in N.s/m
x=-0.2;// m
t=0;// s
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
omega_n=sqrt((2/3)*(k/m));// The undamped natural frequency in rad/s
eta=(1/3)*(c/(m*omega_n));// The damping ratio
omega_d=omega_n*(sqrt(1-eta^2));// The damped natural frequency in rad/s
tau_d=(2*%pi)/omega_d;// The period of the damped system in s
function[X]=Candpsi(y)
    X(1)=(y(1)*sin(y(2)))-(-0.2);
    X(2)=((-0.0667*y(1)*sin(y(2)))+((0.998*y(1)*cos(y(2)))))-0;
endfunction
y=[0.1 1.1];
z=fsolve(y,Candpsi);
C=z(1);// m
psi=z(2);// rad
printf("\n(a)The undamped natural frequency,omega_n=%1.0f rad/s \n(b)The damping ratio,eta=%0.4f \n(c)The damped natural frequency,omega_d=%0.3f rad/s \n(d)The period of the damped system,tau=%1.2f s \nThus, the motion is given by x=%0.3fexp(-%0.4f*t)sin(%0.3ft+%1.3f)m",omega_n,eta,omega_d,tau_d,C,eta,omega_d,psi);
```

Scilab code Exa 8.11 The natural frequency of the vertical vibration

```
// SAMPLE PROBLEM 8/11
clc;funcprot(0);
// Given data
m_c=3;// The mass of collar in kg
m_l=1.2;// The mass of the links in kg
k=1.5;// The stiffness of the spring in kN/m
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
P=(m_c*g)+(2*(1/2)*m_l*g);// The compression P in N
delta_st=P/(k*10^3);// The static deflection of the
    spring in m
omega_n=sqrt(750/1.9);// Hz;
printf("\nThe natural frequency of vertical
    vibration ,omega_n=%2.2f Hz",omega_n);
```