Scilab Textbook Companion for Fluid Power With Applications by A. Esposito[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 2

PHYSICAL PROPERTIES OF HYDRAULIC FLUIDS

Scilab code Exa 2.1.a find weight of a body

```
// Aim:To Find Weight of Body
// Given:
// Mass of the Body:
m=4; //slugs
```

Scilab code Exa 2.1.b SOLUTION weight of a body

```
clc;
pathname=get_absolute_file_path('2_1_soln.sce')
filename=pathname+filesep()+'2_1_data.sci'
exec(filename)

// Solutions:
// we know acceleration due to gravity,
g=32.2; //ft/s^2
W=(m*g);
```

```

// Results:
printf("\n  Results:  ")
printf("\n The weight of Body is %.0f lb.",W)
```

Scilab code Exa 2.2.a find specific weight of body

```
// Aim:To find the specific weight of a body
// Given:
// Weigth of the Body:
W=129; //lb
// Volume of the Body:
V=1.8; //ft^3
```

Scilab code Exa 2.2.b SOLUTION specific weight of body

```
clc;
pathname=get_absolute_file_path('2_2_soln.sce')
filename=pathname+filesep()+'2_2_data.sci'
exec(filename)

// Solution:
// we know specific weight,
// gamma=(Weigth of the Body/Volume of the Body)
gamma1=(W/V); //lb/ft^3
// rounding off the above answer
gamma1=fix(gamma1)+(fix((gamma1-fix(gamma1))*10)/10)
    ; //lb/ft^3

// Results:
printf("\n  Results:  ")
printf("\n The specific weight of Body is %.1f lb/ft
    ^3.",gamma1)
```

Scilab code Exa 2.3.a find specific gravity of air

```
// Aim:To find the specific gravity of air at 68 degF
// Given:
// specific weight of air at 68 degF:
gamma_air=0.0752; //lb/ft^3
```

Scilab code Exa 2.3.b SOLUTION specific gravity of air

```
clc;
pathname=get_absolute_file_path('2_3_soln.sce')
filename=pathname+filesep()+'2_3_data.sci'
exec(filename)

// Solution:
// we know,
// specific gravity of air=(specific weight of air/specific weight of water)
// also we know,specific weight of water at 68 degF,
gamma_water=62.4; //lb/ft^3
SG_air=gamma_air/gamma_water;

// Results:
printf("\n  Results:  ")
printf("\n The specific gravity of air %0.5f.",SG_air)
```

Scilab code Exa 2.4.a find density of body

```
// Aim:To find Density of body of Example 2-1 and 2-2
// Given:
// mass of the Body:
m=4; //slugs
// Volume of the Body:
V=1.8; //ft^3
```

Scilab code Exa 2.4.b SOLUTION density of body

```
clc;
pathname=get_absolute_file_path('2_4_soln.sce')
filename=pathname+filesep()+'2_4_data.sci'
exec(filename)

// Solution:
// we know density,
// rho1=(mass of the Body/Volume of the Body)
rho1=(m/V); //slugs/ft^3
// also density,rho2=(specific weight/acceleration due to gravity)
g=32.2; //ft/s^2
gamma1=71.6; //lb/ft^3
rho2=(gamma1/g); //slugs/ft^3

// Results:
printf("\n  Results:  ")
printf("\n The Density of Body is %.2f slugs/ft^3.",rho1)
printf("\n The Density of Body is %.2f slugs/ft^3.",rho2)
```

Scilab code Exa 2.5.a find pressure on skin diver

```
// Aim:To find pressure on the skin diver
// Given:
// Depth of Water Body:
H=60; //ft
```

Scilab code Exa 2.5.b SOLUTION pressure on skin diver

```
clc;
pathname=get_absolute_file_path('2_5_soln.sce')
filename=pathname+filesep()+'2_5_data.sci'
exec(filename)

// Solution:
// specific Weight of water,
gamma1=0.0361; //lb/in^3
// Conversion:
// 1 feet = 12 inches
// 1 lb/in^2 = 1 psi
// we know pressure,
// p=(specific weight of liquid * liquid column
   height)
p=(gamma1*H*12); //psi

// Results:
printf("\n  Results:  ")
printf("\n The pressure on skin diver is %.1f psi.",
   p)
```

Scilab code Exa 2.6.a find height of barometer tube

```
// Aim:To find tube height of a Barometer
// Given:
// liquid used is Water instead of Mercury.
```

Scilab code Exa 2.6.b SOLUTION height of barometer tube

```
clc;
pathname=get_absolute_file_path('2_6_soln.sce')
filename=pathname+filesep()+'2_6_data.sci'
exec(filename)

// Solution:
// specific Weight of water,
gamma1=0.0361; //lb/in^3
// We also knows Atmospheric Pressure,
p=14.7; //psi
// Conversion:
// 1 feet = 12 inches
// 1 lb/in^2 = 1 psi
// we know pressure,
// p=(specific weight of liquid * liquid column
    height)
// Therefore,
H=(p/gamma1); //in
// He=Height in Feet.
He=H*0.083; //ft

// Results:
printf("\n  Results:  ")
printf("\n The Height of water column is %0.0f ft.",
    He)
```

Scilab code Exa 2.7.a convert gage to absolute pressure

```
// Aim:To convert given pressure into absolute
    pressure
```

```
// Given:
// Gage Pressure:
Pg=-5; //psi
```

Scilab code Exa 2.7.b SOLUTION gage to absolute pressure

```
clc;
pathname=get_absolute_file_path('2_7_soln.sce')
filename=pathname+filesep()+'2_7_data.sci'
exec(filename)

// Solution:
// Atmospheric Pressure,
Po=14.7; //psi
// Absolute Pressure(Pa) =Gage Pressure +
    Atmospheric Pressure
Pa=Pg+Po;

// Results:
printf("\n  Results:  ")
printf("\n The Absolute Pressure is %0.1f psi.",Pa)
```

Scilab code Exa 2.8.a find absolute pressure on skin diver

```
// Aim:To find absolute pressure on skin diver of
    Example 2-5
// Given:
// Gage Pressure:
Pg=26; //psi
```

Scilab code Exa 2.8.b SOLUTION absolute pressure on skin diver

```
clc;
pathname=get_absolute_file_path('2_8_soln.sce')
filename=pathname+filesep()+'2_8_data.sci'
exec(filename)

// Solution:
// Atmospheric Pressure,
Po=14.7; //psi
// Absolute Pressure(Pa) =Gage Pressure +
   Atmospheric Pressure
Pa=Pg+Po; //psi

// Results:
printf("\n  Results:  ")
printf("\n The Absolute Pressure is %0.1f psi.",Pa)
```

Scilab code Exa 2.9.a find specific weight in SI system

```
// Aim:To Determine specific weights in N/m^3
// Given:
// specific weight:
gamma1=56; //lb/ft^3
```

Scilab code Exa 2.9.b SOLUTION specific weight in SI system

```
clc;
pathname=get_absolute_file_path('2_9_soln.sce')
filename=pathname+filesep()+'2_9_data.sci'
exec(filename)

// Solution:
```

```
// We know,
// 1 N/m^3 = 157 lb/ft^3
gamma2=157*gamma1; //N/m^3

// Results:
printf("\n  Results:  ")
printf("\n The specific weights is %0.0f N/m^3.",
    gamma2)
printf("\n The answer in the program is different
    than that in textbook. It may be due to no.s of
    significant digit in data and calculation")
```

Scilab code Exa 2.10.a when fahrenheit and celsius temperature equals

```
// Aim:To find Temperature at which Fahrenheit and
    Celsius values are equal
// Given:
// T(degF) = T(degC)  //Eqn - 1
```

Scilab code Exa 2.10.b SOLUTION fahrenheit and celsius temp equals

```
clc;
pathname=get_absolute_file_path('2_10_soln.sce')
filename=pathname+filesep()+'2_10_data.sci'
exec(filename)

// Solution:
// We know that,
// T(degF)=((1.8*T(degC))+32)  //Eqn - 2
// From Eqn 1 and 2
// ((1.8*T(degC))+32)= T(degC)
// (1-1.8)*T(degC)=32
// -0.8*T(degC)=32
```

```
TdegC=-32/0.8;

// Results:
printf("\n  Results:  ")
printf("\n The temp at which Fahrenheit and Celsius
    values are equal is %0.1f deg.",TdegC)
```

Scilab code Exa 2.11.a find change in volume of oil

```
// Aim:To find change in volume of the oil
// Given:
// Volume of original oil:
V=10; //in^3
// Initial Pressure:
P1=100; //psi
// Final pressure:
P2=2000; //psi
// Bulk Modullus:
betaa=250000; //psi
```

Scilab code Exa 2.11.b SOLUTION change in volume of oil

```
clc;
pathname=get_absolute_file_path('2_11_soln.sce')
filename=pathname+filesep()+'2_11_data.sci'
exec(filename)

// Solution:
// Change in pressure,
delP=P2-P1; //psi
// Change in volume,
delV=-((V*delP)/betaa); //in^3 ,- sign indicates oil
    is being compressed
```

```

// Results:
printf("\n  Results:  ")
printf("\n The change in volume of oil is %.3f in^3.
   ",delV)
```

Scilab code Exa 2.12.a find viscosity of oil

```
// Aim:To find viscosity of oil in centistokes and
   centipoise
// Given:
// viscosity of oil:
nu=230; //SUS at
t=150; //degF.
// specific gravity of oil:
gamma1=0.9;
```

Scilab code Exa 2.12.b SOLUTION viscosity of oil

```
clc;
pathname=get_absolute_file_path('2_12_soln.sce')
filename=pathname+filesep()+'2_12_data.sci'
exec(filename)

// Solution:
// kinematic viscosity of oil in centistokes,
nu_cs=((0.220*nu)-(135/t)); //centistokes
// absolute viscosity of oil in centipoise,
mu_cp=(gamma1*nu_cs); //centipoise

// Results:
printf("\n  Results:  ")
```

```
printf("\n The viscosity of oil in centistokes is %0
    .0f cS.",nu_cs)
printf("\n The viscosity of oil in centipoise is %0
    .0f cP.",mu_cp)
```

Scilab code Exa 2.13.a find kinematic and absolute viscosities

```
// Aim:To find kinematic and absolute viscosity of
    oil in cS and cP respectively
// Given:
// Density of oil:
Den=0.89; //g/cm^3
// Time flow:
t=250; //s
// Calibration constant:
cc=0.100;
```

Scilab code Exa 2.13.b SOLUTION kinematic and absolute viscosities

```
clc;
pathname=get_absolute_file_path('2_13_soln.sce')
filename=pathname+filesep()+'2_13_data.sci'
exec(filename)


// Solution:
// kinematic viscosity of oil in centistokes,
nu_cs=(t*cc); //centistokes
// absolute viscosity of oil in centipoise,
SG=Den;
mu_cp=(SG*nu_cs); //centipoise
// rounding off the above answer
```

```
mu_cp=fix(mu_cp)+(fix(round((mu_cp-fix(mu_cp))*10))
    /10); //centipoise

// Results:
printf("\n  Results:  ")
printf("\n The viscosity of oil in centistokes is %0
    .1f cS.",nu_cs)
printf("\n The viscosity of oil in centipoise is %0
    .1f cP.",mu_cp)
```

Scilab code Exa 2.14.a find viscosity of oil at 100F

```
// Aim:To find viscosity of oil at 100 degF in SUS
// Given:
// Viscosity Index:
VI=80;
// viscosity of O-VI oil at 100 degF:
L=400; //SUS
// viscosity of 100-VI oil at 100 degF:
H=150; //SUS
```

Scilab code Exa 2.14.b SOLUTION viscosity of oil at 100F

```
clc;
pathname=get_absolute_file_path('2_14_soln.sce')
filename=pathname+filesep()+'2_14_data.sci'
exec(filename)

// Solution:
// viscosity of sample oil at 100 degF,
U=L-(((L-H)*VI)/100); //SUS

// Results:
```

```
printf("\n  Results:  ")
printf("\n The viscosity of sample oil at 100 degF
   is %0.0f SUS.",U)
```

Scilab code Exa 2.15.a find pressure on skin diver SI

```
// Aim:To find pressure on the skin diver in SI
   units
// Given:
// Depth of Water Body:
H=18.3; //m
```

Scilab code Exa 2.15.b SOLUTION pressure on skin diver SI

```
clc;
pathname=get_absolute_file_path('2_15_soln.sce')
filename=pathname+filesep()+'2_15_data.sci'
exec(filename)

// Solution:
// specific Weight of water,
gamma1=9800; //N/m^3
// we know pressure,
// p=(specific weight of liquid * liquid column
   height)
p=(gamma1*H); //Pa
pK=p/1000; //kPa

// Results:
printf("\n  Results:  ")
printf("\n The pressure on skin diver is %.0f kPa.",
   pK)
```

Scilab code Exa 2.16.a convert gage to absolute pressure SI

```
// Aim:To convert given pressure into absolute
    pressure
// Given:
// Gage Pressure:
Pg=-34000; //Pa
```

Scilab code Exa 2.16.b SOLUTION gage to absolute pressure SI

```
clc;
pathname=get_absolute_file_path('2_16_soln.sce')
filename=pathname+filesep()+'2_16_data.sci'
exec(filename)

// Solution:
// Atmospheric Pressure,
Po=101000; //Pa
// Absolute Pressure(Pa) =Gage Pressure +
    Atmospheric Pressure
Pa=Pg+Po; //Pa

// Results:
printf("\n  Results:  ")
printf("\n The Absolute Pressure is %0.0f Pa.",Pa)
```

Scilab code Exa 2.17.a find oil volume change in SI

```
// Aim:To find % change in volume of the oil
```

```
// Given:
// Volume of original oil:V=164 //cm^3
// Initial Pressure:
P1=687; //kPa
// Final pressure:
P2=13740; //kPa
// Bulk Modullus:
betaa=1718; //MPa
```

Scilab code Exa 2.17.b SOLUTION oil volume change in SI

```
clc;
pathname=get_absolute_file_path('2_17_soln.sce')
filename=pathname+filesep()+'2_17_data.sci'
exec(filename)

// Solution:
// Change in pressure,
delP=P2-P1; //kPa
betaa=betaa*1000; //kPA
// % Change in volume,
delV=-(delP/betaa)*100; //% ,- sign indicates oil is being compressed

// Results:
printf("\n  Results:  ")
printf("\n The Percentage change in volume of oil is %.3f.",delV)
```

Scilab code Exa 2.18.a find absolute viscosity in SI

```
// Aim:To find absolute viscosity of oil in Ns/m^2 and cP
```

```
// Given:
// Area of moving plate surface in contact with oil:
A=1; //m^2
// Force applied to the moving plate:
F=10; //N
// velocity of the moving plate:
v=1; //m/s
// oil film thickness:
y=5; //mm
y=5*0.001; //m
```

Scilab code Exa 2.18.b SOLUTION absolute viscosity in SI

```
clc;
pathname=get_absolute_file_path('2_18_soln.sce')
filename=pathname+filesep()+'2_18_data.sci'
exec(filename)

// Solution:
// absolute viscosity of oil,
mu=(F/A)/(v/y); //Ns/m^2
// absolute viscosity of oil in cP,
mu_P=(F*100000*y*100)/(v*100*A*10000); //poise
mu_cP=mu_P*100; //centipoise

// Results:
printf("\n  Results:  ")
printf("\n The viscosity of oil is %0.2f Ns/m^2.",mu
   )
printf("\n The viscosity of oil is %0.2f cP.",mu_cP)
```

Chapter 3

ENERGY AND POWER IN HYDRAULIC SYSTEMS

Scilab code Exa 3.1.a find work done and power delivered

```
// Aim:To find work done and power deliver
// Given:
// Force excerted by the person:
F=30; //lb
// Distance moved by hand truck:
S=100; //ft
// time taken:
t=60; //s
```

Scilab code Exa 3.1.b SOLUTION work done and power delivered

```
clc;
pathname=get_absolute_file_path('3_1_soln.sce')
filename=pathname+filesep()+'3_1_data.sci'
exec(filename)

```

```
// Solution:
// we know,Work done=Force * Displacement,
W=F*S; //ft.lb
// Now,Power,
P=W/t; //(ft.lb/s)
P=P/550; //HP

// Results:
printf("\n  Results:  ")
printf("\n The work done by the person is %.1f ft.lb
   ",W)
printf("\n The power delivered by the person is %.3f
    HP",P)
```

Scilab code Exa 3.2.a find torque delivered by hydraulic motor

```
clc;
// Aim:To determine torque required by hydraulic
   motor
// Given:
// Power Supplied:
HP=2; //HP
// Speed of the Hydraulic motor:
N=1800; //rpm
```

Scilab code Exa 3.2.b SOLUTION torque delivered by hydraulic motor

```
clc;
pathname=get_absolute_file_path('3_2_soln.sce')
filename=pathname+filesep()+'3_2_data.sci'
exec(filename)

// Solution:
```

```
// Power (HP)=(Torque*Speed)/63000
// Therefore,Torque
T=(HP*63000)/N; //in.lb

// Results:
printf("\n  Results:  ")
printf("\n The Torque delivered by Hydraulic motor
   is %.1f in.lb",T)
```

Scilab code Exa 3.3.a find input horsepower required by elevator

```
// Aim: Refer Example 3-3 for Problem Description
// Given:
// Load to be raised:
F=3000; //lb
// Distance:
S=50; //ft
// time required:
t=10; //s
//efficiency of the system:
eta=80; //%
```

Scilab code Exa 3.3.b SOLUTION input horsepower required by elevator

```
clc;
pathname=get_absolute_file_path('3_3_soln.sce')
filename=pathname+filesep()+'3_3_data.sci'
exec(filename)

// Solution:
// we know,output power=(Force * Displacement)/time,
outpw=(F*S)/t; //ft.lb/s
outpw_HP=outpw/550; //HP
```

```
// Efficiency=output power/input power
inpw=outpw_HP/(eta*0.01); //HP

// Results:
printf("\n  Results:  ")
printf("\n The Input Horsepower required by elevator
    hoist motor is %.1f HP",inpw)
```

Scilab code Exa 3.4.a find force and energy for jack

```
// Aim:Refer Example 3-4 for Problem Description
// Given:For the Hydraulic Jack,
// Area of Piston 1:
A1=2; //in^2
// Area of Piston 2:
A2=20; //in^2
// Input force downward:
F1=100; //lb
// downward movement of piston 1:
S1=1; //in
```

Scilab code Exa 3.4.b SOLUTION force and energy for jack

```
clc;
pathname=get_absolute_file_path('3_4_soln.sce')
filename=pathname+filesep()+'3_4_data.sci'
exec(filename)

// Solution:
// Pascal law states, (F1*A1 = F2*A2)
// Similarly, (S1*A1 = S2*A2)
// Output force upward,
F2=(A2/A1)*F1; //lb
```

```
// upward movement of piston 2,
S2=(A1/A2)*S1; //in
// Energy Input,
E1=F1*S1; //in.lb
// Energy Output,
E2=F2*S2; //in.lb

// Results:
printf("\n  Results:  ")
printf("\n The Output force upward is %.1f lb",F2)
printf("\n The upward movement of piston 2 is %.1f
    in",S2)
printf("\n The Energy Input is %.1f in.lb",E1)
printf("\n The Energy Output is %.1f in.lb",E2)
```

Scilab code Exa 3.5.a what is output horsepower

```
// Aim:Refer Example 3-5 for Problem Description.
// Given:
// Diameter of piston of pump cylinder:
Dp=1; //in
// Diameter of piston of load cylinder:
Dl=3.25; //in
// Average hand force:
Fh=25; //lb
// Load piston stroke:
Sl=10; //in
// Pump piston stroke:
Sp=2; //in
```

Scilab code Exa 3.5.b SOLUTION output horsepower

```
clc;
```

```
pathname=get_absolute_file_path('3_5_soln.sce')
filename=pathname+filesep()+'3_5_data.sci'
exec(filename)

// Solution:
// Therfore, Force acting on rod of pump cylinder,
F_rod=(8/2)*Fh; //lb
// Area of piston of pump cylinder,
Ap=(%pi/4)*Dp^2;//in^2
// Area of piston of load cylinder,
Al=(%pi/4)*Dl^2; //in^2
// Pump cylinder discharge pressure,
p=round(F_rod/Ap); //psi
// Load carrying capacity,
F_load=p*Al; //lb
// Therefore, No.s of Cycles,
Noc=(Al*Sl)/(Ap*Sp);
// Output power,
outpw=((F_load*(Sl/12))/Noc); //ft.lb/s
outpw_HP=outpw/550; //HP
// Assuming efficiency 80 %
eta=0.8;
outpw_HP2=eta*outpw_HP; //HP

// Results:
printf("\n  Results:  ")
printf("\n Therefore %.0f lb of load can be lifted",
    F_load)
printf("\n The answer in the program is different
    than that in textbook. It may be due to no.s of
    significant digit in data and calculation")
printf("\n Therefore %.1f no.s of cycles are
    required to lift the load 10 in.",Noc)
printf("\n The answer in the program is different
    than that in textbook. It may be due to no.s of
    significant digit in data and calculation")
printf("\n Input power when efficiency is 100
    percent is %.3f HP",outpw_HP)
```

```
printf("\n Input power when efficiency is 80 percent
    is %.3f HP",outpw_HP2)
```

Scilab code Exa 3.6.a find load carrying capacity of system

```
// Aim:Refer Example 3-6 for Problem Description.
// Given:
// inlet air pressure:
p1=100; //psi
// air piston area:
A1=20; //in^2
// oil piston area:
A2=1; //in^2
// load piston area:
A3=25; //in^2
// load piston diameter:
d3=5.64; //in
```

Scilab code Exa 3.6.b SOLUTION load carrying capacity of system

```
clc;
pathname=get_absolute_file_path('3_6_soln.sce')
filename=pathname+filesep()+'3_6_data.sci'
exec(filename)

// Solution:
// booster input force = booster output force
// p1*A1 = p2*A2
p2=(A1/A2)*p1; //psi
// As per pascal law,
p3=p2; // where p3=outlet pressure
// Therefore load carrying capacity of system,
F=p3*A3; //lb
```

```

// Results:
printf("\n  Results:  ")
printf("\n The load carrying capacity of system is %.0f lb.",F)
```

Scilab code Exa 3.7.a find flow rate and fluid velocity

```
// Aim:Refer Example 3-7 for Problem Description.
// Given:
// inlet diameter:
D1=4; //in
// outlet diameter:
D2=2; //in
// inlet velocity:
v1=4; //ft/s
```

Scilab code Exa 3.7.b SOLUTION flow rate and fluid velocity

```
clc;
pathname=get_absolute_file_path('3_7_soln.sce')
filename=pathname+filesep()+'3_7_data.sci'
exec(filename)

// Solution:
// we know, Discharge=Area*Velocity
A1=(%pi/4)*(D1/12)^2; //ft^2
Q=A1*v1; //ft^3/s
// Since, for hydraulic system, volume flow rate is always constant
// we get,outlet velocity,
v2=((D1/D2)^2)*v1; //ft/s

```

```
// Results:
printf("\n  Results:  ")
printf("\n The Volume flow rate of the system is %.3
   f ft^3/s.",Q)
printf("\n The fluid velocity at station 2 is %.0f
   ft/s.",v2)
```

Scilab code Exa 3.8.a calculate output HP delivered by cylinder

```
// Aim:Refer Example 3-8 for Problem Description.
// Given:
// Time period of operations:
t=10; //s
// Stroke of hydraulic cylinder:
S=10; //ft
// Load required to compress car:
F_load=8000; //lb
// Pump pressure:
p=1000; //psi
// Efficiency of cylinder:100 %
eta=1;
```

Scilab code Exa 3.8.b SOLUTION output HP delivered by cylinder

```
clc;
pathname=get_absolute_file_path('3_8_soln.sce')
filename=pathname+filesep()+'3_8_data.sci'
exec(filename)

// Solution:
// The required piston area,
A=round(F_load/p); //in^2
// The necessary pump flow rate,
```

```
Q=((A/144)*S)/t; //ft^3/s
Q_gpm=Q*449; //gpm
// The Hydraulic Horsepower delivered to cylinder,
HHP=(p*Q_gpm)/1714; //HP
// rounding off the above answer
HHP=fix(HHP)+(fix(floor((HHP-fix(HHP))*10))/10); //
    HP
// The output horsepower delivered by cylinder to
    load,
OHP=HHP*eta; //HP

// Results:
printf("\n  Results:  ")
printf("\n The Required piston area is %.0f in^2.",A
    )
printf("\n The necessary pump flow rate is %.1f gpm.
    ",Q_gpm)
printf("\n The Hydraulic Horsepower delivered to
    cylinder is %.1f HP.",HHP)
printf("\n The output horsepower delivered by
    cylinder to load is %.1f HP.",OHP)
```

Scilab code Exa 3.9.a calculate efficiency of cylinder assuming leakage

```
// Aim:Refer Example 3-9 for Problem Description.
// Given:
// Time period of operations:
t=10; //s
// Stroke of hydraulic cylinder:
S=10; //ft
// Load required to compress car:
F_load=8000; //lb
// Pump pressure:
p=1000; //psi
// Frictional Force:
```

```
F_fric=100; //lb
// Leakage:
Q_leak=0.2; //gpm
```

Scilab code Exa 3.9.b SOLUTION efficiency of cylinder assuming leakage

```
clc;
pathname=get_absolute_file_path('3_9_soln.sce')
filename=pathname+filesep()+'3_9_data.sci'
exec(filename)

// Solution:
// The required piston area,
A=(F_load+F_fric)/p; //in^2
// The Theoretical pump flow rate,
Q_theo=((A/144)*S)/t; //ft^3/s
Q_gpm=(Q_theo*449); //gpm
// The Actual pump flow rate,
Q_act=Q_gpm+Q_leak; //gpm
// rounding off the above answer
Q_act=fix(Q_act)+(fix(floor((Q_act-fix(Q_act))*10))/10); //gpm
// The Hydraulic Horsepower delivered to cylinder,
HHP=(p*Q_gpm)/1714; //HP
// rounding off the above answer
HHP=fix(HHP)+(fix(ceil((HHP-fix(HHP))*10))/10); //HP
// The output horsepower delivered by cylinder to load,
OHP=(F_load*(S/t))/550; //HP
// The Efficiency of System,
eta=floor((OHP/HHP)*100); //%

// Results:
printf("\n  Results:  ")
printf("\n The Required piston area is %.2f in^2.",A
```

```
)
printf("\n The necessary pump flow rate is %.1f gpm.
   ",Q_act)
printf("\n The Hydraulic Horsepower delivered to
   cylinder is %.1f HP.",HHP)
printf("\n The output horsepower delivered by
   cylinder to load is %.1f HP.",OHP)
```

Scilab code Exa 3.10.a find pressure available at motor inlet

```
// Aim:Refer Example 3-10 for Problem Description.
// Given:
// Pump Power:
HHP=5; //HP
// Pump flow:
Q=30; //gpm
// Pipe Diameter:
D=1; //in
// specific gravity of oil:
SG=0.9;
// Pressure at Station 1:
p1=0; //psig (It is atmospheric pressure.)
// Head Loss due to friction between Station 1 and 2
    of oil:
Hl=30; //ft
```

Scilab code Exa 3.10.b SOLUTION pressure available at motor inlet

```
clc;
pathname=get_absolute_file_path('3_10_soln.sce')
filename=pathname+filesep()+'3_10_data.sci'
exec(filename)

```

```
// Solution:
// Acceleration due to gravity,
g=32.2; //ft/s^2
// Energy Equation between Station 1 and Station 2
   is given by,
// (Z1+P1+K1+Hp-Hm-Hl)=(Z2+P2+K2)
// since, There is no Hydraulic motor between
   Station 1 and 2,
// Therefore Motor Head,
Hm=0; //ft
// also, cross section of oil tank is very large, as
    a result oil is at rest,
v1=0; //ft/s
// Kinetic Energy Head at inlet,
K1=(v1^2)/(2*g); //ft
// Height of Station 1 from Datum,
Z1=0; //ft
// Height of Station 2 from Datum,
Z2=20; //ft
// Pressure Head at inlet,
P1=p1/SG; //ft
// Pump Head,
Hp=ceil((3950*HHP)/(Q*SG)); //ft
// Pump flow,
Q_1=Q/449; //ft^3/s
// Area of pipe,
A=((%pi)*((D/12)^2))/4; //ft^2
// Therefore, velocity in pipe,
v2=Q_1/A; //ft/s
// Kinetic Energy head at Station 2,
K2=(v2^2)/(2*g); //ft
// Therefore, Pressure Head at outlet,
P2=Z1+P1+K1+Hp-Hm-Hl-Z2-K2; //ft
// specific weight of oil,
gamma1=SG*62.4; //lb/ft^3
// Pressure available at inlet of hydraulic motor at
    station 2,
p2=P2*gamma1; // lb/ft^2
```

```
p2=floor(p2/144); //psi

// Results:
printf("\n  Results:  ")
printf("\n The Pressure available at inlet of
   hydraulic motor at Station 2 is %.0f psig.",p2)
```

Scilab code Exa 3.11.a find jet velocity and flow rate

```
// Aim:Refer Example 3-11 for Problem Description.
// Given:
// Fluid Head:
h=36; //ft
// Diameter of opening:
d=2; //in
// Frictional Head Losses:
Hl=10; //ft
```

Scilab code Exa 3.11.b SOLUTION jet velocity and flow rate

```
clc;
pathname=get_absolute_file_path('3_11_soln.sce')
filename=pathname+filesep()+'3_11_data.sci'
exec(filename)

// Solution:
// Acceleration due to gravity,
g=32.2; //ft/s^2
// Assuming ideal fluid, Jet velocity,
v2=sqrt(2*g*h); //ft/s
// Area of the opening,
A=(%pi/4)*((d/12)^2); //ft^2
// flow rate,
```

```
Q=A*v2; //ft^3/s
Q_gpm=floor(449*Q); //gpm
// Jet velocity considering friction losses,
v2l=sqrt(64.4*(h-Hl)); //ft/s
// since, flow rate is proportional to velocity,
Ql=((v2l/v2)*Q_gpm); //gpm

// Results:
printf("\n  Results:  ")
printf("\n The Jet velocity is %.1f ft/s.",v2)
printf("\n The answer in the program is different
   than that in textbook. It may be due to no.s of
   significant digit in data and calculation")
printf("\n The Flow rate is %.0f gpm.",Q_gpm)
printf("\n The Jet velocity considering friction
   losses is %.1f ft/s.",v2l)
printf("\n The Flow rate considering friction losses
    is %.0f gpm.",Ql)
printf("\n The answer in the program is different
   than that in textbook. It may be due to no.s of
   significant digit in data and calculation")
```

Scilab code Exa 3.12.a find velocity and flowrate through siphon

```
// Aim:Refer Example 3-12 for Problem Description.
// Given:
// Fluid Head:
h=30; //ft
// Frictional Head Losses:
Hl=10; //ft
// U-tube inside diameter:
d=1; //in
```

Scilab code Exa 3.12.b SOLUTION velocity and flowrate through siphon

```
clc;
pathname=get_absolute_file_path('3_12_soln.sce')
filename=pathname+filesep()+'3_12_data.sci'
exec(filename)

// Solution:
// Acceleration due to gravity,
g=32.2; //ft/s^2
// Jet velocity through siphon,
v2=sqrt(2*g*(h-H1)); //ft/s
// rounding off the above answer
v2=fix(v2)+(fix(floor((v2-fix(v2))*10))/10); //ft/s
// Area of the U tube,
A=(%pi/4)*((d/12)^2); //ft^2
// flow rate through siphon,
Q=A*v2; //ft^3/s
Q_gpm=449*Q; //gpm
// rounding off the above answer
Q_gpm=fix(Q_gpm)+(fix(floor((Q_gpm-fix(Q_gpm))*10))
    /10); //gpm

// Results:
printf("\n   Results:  ")
printf("\n The velocity through siphon is %.1f ft/s.
    ",v2)
printf("\n The Flow rate through siphon is %.1f gpm.
    ",Q_gpm)
```

Scilab code Exa 3.13.a determine force and displacement for piston2

```
// Aim:Refer Example 3-13 for Problem Description
// Given:For the Hydraulic Jack,
// Area of Piston 1:
```

```
A1=25; //cm^2
// Area of Piston 2:
A2=100; //cm^2
// Input force downward:
F1=200; //N
// downward movement of piston 1:
S1=5; //cm
```

Scilab code Exa 3.13.b SOLUTION force and displacement for piston2

```
clc;
pathname=get_absolute_file_path('3_13_soln.sce')
filename=pathname+filesep()+'3_13_data.sci'
exec(filename)

// Solution:
// Pascal law states, (F1*A1 = F2*A2)
// Similarly, (S1*A1 = S2*A2)
// Output force upward,
F2=(A2/A1)*F1; //N
// upward movement of piston 2,
S2=(A1/A2)*S1; //cm

// Results:
printf("\n  Results:  ")
printf("\n The Output force upward is %.0f N",F2)
printf("\n The upward movement of piston 2 is %.2f
    cm",S2)
```

Scilab code Exa 3.14.a find velocity of oil through pipe

```
// Aim:To Determine velocity through pipe.
// Given:
```

```
// Diameter of pipe:
D=30; //mm
// Flow through pipe:
Q=60; //lpm
```

Scilab code Exa 3.14.b SOLUTION velocity of oil through pipe

```
clc;
pathname=get_absolute_file_path('3_14_soln.sce')
filename=pathname+filesep()+'3_14_data.sci'
exec(filename)

// Solution:
// Pump flow in m^3/s,
Q_si=0.0000167*Q; //m^3/s
// Diameter of pipe,
D_m=D/1000; //m
// Area of pipe,
A=(%pi*(D_m^2))/4; //m^2
// velocity,
v=Q_si/A; //m/s
// rounding off the above answer
v=fix(v)+(fix(floor((v-fix(v))*100))/100); //m/s

// Results:
printf("\n  Results:  ")
printf("\n The velocity through pipe is %.2f m/s.",v
   )
```

Scilab code Exa 3.15.a find hydraulic power delivered by pump

```
// Aim:To Determine Hydraulic power delivered by
   pump.
```

```
// Given:
// Pump flow:
Q=50; //lpm
// Pressure delivered by pump:
p=10000; //kPa
```

Scilab code Exa 3.15.b SOLUTION hydraulic power delivered by pump

```
clc;
pathname=get_absolute_file_path('3_15_soln.sce')
filename=pathname+filesep()+'3_15_data.sci'
exec(filename)

// Solution:
// Pump flow in m^3/s,
Q_si=0.0000167*Q; //m^3/s
// Hydraulic Power,
HP=p*Q_si; //kW

// Results:
printf("\n  Results:  ")
printf("\n The Hydraulic power delivered by pump is %.2f kW.",HP)
```

Scilab code Exa 3.16.a find torque delivered by motor SI

```
// Aim:To determine torque delivered by hydraulic motor
// Given:
// Mechanical Output Power:
OP=10; //kW
// Speed of the Hydraulic motor:
N=1450; //rpm
```

Scilab code Exa 3.16.b SOLUTION torque delivered by motor SI

```
clc;
pathname=get_absolute_file_path('3_16_soln.sce')
filename=pathname+filesep()+'3_16_data.sci'
exec(filename)

// Solution:
// Power(kW)=(Torque*Speed)/9550
// Therefore, Torque
T=(OP*9550)/N; //Nm

// Results:
printf("\n  Results:  ")
printf("\n The Torque delivered by Hydraulic motor
    is %.1f Nm.",T)
```

Scilab code Exa 3.17.a find pressure at hydraulicmotor inlet SI

```
// Aim:Refer Example 3-17 for Problem Description.
// Given:
// Pump Power:
HHP=3.73; //kW
// Pump flow:
Q=0.001896; //m^3/s
// Pipe Diameter:
D=0.0254; //m
// specific gravity of oil:
SG=0.9;
// Pressure at Station 1:
p1=0; //Pa (It is atmospheric pressure.)
```

```
// Elevation Between Station 1 and 2:
// Z=Z1-Z2
Z=-6.096; //m  -ve sign indicates Station 2 is above Station 1
// Head Loss due to friction between Station 1 and 2 of oil:
Hl=9.144; //m
```

Scilab code Exa 3.17.b SOLUTION pressure at hydraulicmotor inlet SI

```
clc;
pathname=get_absolute_file_path('3_17_soln.sce')
filename=pathname+filesep()+'3_17_data.sci'
exec(filename)

// Solution:
// Acceleration due to gravity,
g=9.81; //m/s^2
// Energy Equation between Station 1 and Station 2 is given by,
// (Z+P1+K1+Hp-Hm-Hl)=(P2+K2)
// since, There is no Hydraulic motor between Station 1 and 2,
// Therefore Motor Head,
Hm=0; //m
// also, cross section of oil tank is very large, as a result oil is at rest,
v1=0; //m/s
// Kinetic Energy Head at inlet,
K1=(v1^2)/(2*g); //m
// Pressure Head at inlet,
P1=p1/SG; //m
// specific weight of oil,
gamma1=round(SG*9797); //N/m^3
// Pump Power,
```

```
W=HHP*1000; //W
// Pump Head,
Hp=(W/(Q*gamma1)); //m
// Area of pipe,
A=((%pi)*(D^2))/4; //m^2
// Therefore, velocity in pipe,
v2=Q/A; //m/s
// Kinetic Energy head at Station 2,
K2=(v2^2)/(2*g); //m
// Therefore, Pressure Head at outlet,
P2=Z+P1+K1+Hp-Hm-Hl-K2; //m
// Pressure available at inlet of hydraulic motor at
    station 2,
p2=floor((P2*gamma1)/1000); // kPa gage

// Results:
printf("\n  Results:  ")
printf("\n The Pressure available at inlet of
   hydraulic motor at Station 2 is %.0f kPa gage.",
   p2)
```

Chapter 4

FRICTIONAL LOSSES IN HYDRAULIC PIPELINES

Scilab code Exa 4.1.a find reynolds number of hydraulic oil

```
// Aim:To Find Reynolds number of oil
// Given:
// Kinematic viscosity of oil:
nu=100; //cS
// velocity of oil:
v=10; //ft/s
// Pipe diameter:
D=1; //in
```

Scilab code Exa 4.1.b SOLUTION reynolds number of hydraulic oil

```
clc;
pathname=get_absolute_file_path('4_1_soln.sce')
filename=pathname+filesep()+'4_1_data.sci'
exec(filename)

```

```
// Solution:
// Reynolds Number,
N_R=(7740*v*D)/nu;

// Results:
printf("\n  Results:  ")
printf("\n The Reynolds number of given oil is %.0f.
   ",N_R)
```

Scilab code Exa 4.2.a find reynolds number of oil SI

```
// Aim:To Find Reynolds number of oil
// Given:
// Kinematic viscosity of oil:
nu=0.001; //m^2/s
// velocity of oil:
v=5; //m/s
// Pipe diameter:
D=50; //mm
```

Scilab code Exa 4.2.b SOLUTION reynolds number of oil SI

```
clc;
pathname=get_absolute_file_path('4_2_soln.sce')
filename=pathname+filesep()+'4_2_data.sci'
exec(filename)

// Solution:
// Reynolds Number,
N_R=(v*(D/1000))/nu;

// Results:
printf("\n  Results:  ")
```

```
printf("\n The Reynolds number of given oil is %.0f.
   ",N_R)
```

Scilab code Exa 4.3.a find head loss in friction

```
// Aim:Refer Example 4-3 for Problem Description
// Given:
// Kinematic viscosity of oil:
nu=100; //cS
// velocity of oil:
v=10; //ft/s
// Pipe diameter:
D=1; //in
// Length of pipe:
L=100; //ft
// specific gravity of oil:
SG_oil=0.9;
```

Scilab code Exa 4.3.b SOLUTION head loss in friction

```
clc;
pathname=get_absolute_file_path('4_3_soln.sce')
filename=pathname+filesep()+'4_3_data.sci'
exec(filename)

// Solution:
// acceleration due to gravity,
g=32.2; //ft/s^2
// Reynolds Number,
N_R=(7740*v*D)/nu;
// Head loss in pipe,
H_L=round((64*L*(v^2))/(N_R*(D/12)*2*g)); //ft ,
   Hagen-Poiseuille Equation
```

```
// Head loss in terms of psi,
H_L=SG_oil*0.0361*12*H_L; //psi

// Results:
printf("\n  Results:  ")
printf("\n The Head Loss due to friction in pipe is
   %.0f psi.",H_L)
```

Scilab code Exa 4.4.a find head loss in friction SI

```
// Aim:Refer Example 4-4 for Problem Description
// Given:
// Kinematic viscosity of oil:
nu=0.001; //m^2/s
// velocity of oil:
v=5; //m/s
// Pipe diameter:
D=50; //mm
// Length of pipe:
L=50; //m
// specific weigth of oil:
gamma1=8800; //N/m^2
```

Scilab code Exa 4.4.b SOLUTION head loss in friction SI

```
clc;
pathname=get_absolute_file_path('4_4_soln.sce')
filename=pathname+filesep()+'4_4_data.sci'
exec(filename)

// Solution:
// acceleration due to gravity,
g=9.80; //m/s^2
```

```
// Reynolds Number,
N_R=(v*(D/1000))/nu;
// Head loss in pipe,
H_L=floor((64*L*(v^2))/(N_R*(D/1000)*2*g)); //m ,
    Hagen-Poiseuille Equation
// Head loss in terms of kPa,
H_L1=(gamma1*H_L)/1000; //kPa

// Results:
printf("\n  Results:  ")
printf("\n The Head Loss due to friction in pipe is
    %.0f m of oil.",H_L)
```

Scilab code Exa 4.5.a find friction factor of pipe

```
// Aim:Refer Example 4-5 for Problem Description
// Given:
// Kinematic viscosity of oil:
nu=50; //cS
// Pipe diameter:
D=1; //in
// velocity of oil:
v1=10; //ft/s
v2=40; //ft/s
```

Scilab code Exa 4.5.b SOLUTION friction factor of pipe

```
clc;
pathname=get_absolute_file_path('4_5_soln.sce')
filename=pathname+filesep()+'4_5_data.sci'
exec(filename)

// Solution:
```

```
// Reynolds Number in 1st case,
N_R1=(7740*v1*D)/nu;
// Using Moody diagram from fig 4-9,
f1=0.042 ;
// Reynolds Number in 2nd case,
N_R2=(7740*v2*D)/nu;
// relative roughness,
rr=0.0018/D;
// Using Moody diagram from fig 4-9,
f2=0.036;

// Results:
printf("\n  Results:  ")
printf("\n The friction factor in 1st case is %.3f."
   ,f1)
printf("\n The friction factor in 2nd case is %.3f."
   ,f2)
```

Scilab code Exa 4.6.a find head loss across globe valve

```
// Aim:To Find Head Loss across valve
// Given:
// Diameter of globe valve:
D=1; //in
// specific gravity of oil:
SG_oil=0.9;
// flow rate:
Q=30; //gpm
```

Scilab code Exa 4.6.b SOLUTION head loss across globe valve

```
clc;
pathname=get_absolute_file_path('4_6_soln.sce')
```

```
filename=pathname+filesep()+'4_6_data.sci'
exec(filename)

// Solution:
// fluid velocity,
v=(Q/449)/((%pi*((D/12)^2))/4); //ft/s
// rounding off the above answer
v=fix(v)+(fix(floor((v-fix(v))*10))/10); //ft/s
// From table of "K factors of common valves and fittings",
K=10;
// acceleration due to gravity,
g=32.2; //ft/s^2
// Head Loss across globe valve,
H_L=(K*(v^2))/(2*g); //ft
// Pressure drop across Valve,
delp=SG_oil*0.0361*12*H_L; //psi

// Results:
printf("\n Results: ")
printf("\n The head loss across globe valve is %.1f ft of oil.",H_L)
```

Scilab code Exa 4.7.a find head loss across gate valve

```
// Aim:To Find Head Loss across valve
// Given:
// Diameter of gate valve:
D=50; //mm
// specific weight of oil:
gamma1=8800; //N/m^2
// kinemativ viscosity of oil:
nu=0.001; //m^2/s
// flow rate:
Q=0.02; //m^3/s
```

Scilab code Exa 4.7.b SOLUTION head loss across gate valve

```
clc;
pathname=get_absolute_file_path('4_7_soln.sce')
filename=pathname+filesep()+'4_7_data.sci'
exec(filename)

// Solution:
// fluid velocity,
v=Q/((%pi*((D/1000)^2))/4); //m/s
// rounding off the above answer
v=fix(v)+(fix(round((v-fix(v))*10))/10); //m/s
// From table of "K factors of common valves and
   fittings",
K=0.19;
// acceleration due to gravity,
g=9.80; //m/s^2
// Head Loss across globe valve,
H_L=(K*(v^2))/(2*g); //m
// Pressure drop across Valve,
delp=(gamma1*H_L)/1000; //kPa

// Results:
printf("\n  Results:  ")
printf("\n The head loss across globe valve is %.2f
   m of oil.",H_L)
```

Scilab code Exa 4.8.a find equivalent length of globe valve

```
// Aim:Refer Example 4-8 for Problem Description
// Given:
```

```
// Kinematic viscosity of oil:
nu=100; //cS
// Diameter of steel pipe:
D=1; //in
// flow rate:
Q=30; //gpm
// Diameter of wide open globe valve:
D_1=1; //in
```

Scilab code Exa 4.8.b SOLUTION equivalent length of globe valve

```
clc;
pathname=get_absolute_file_path('4_8_soln.sce')
filename=pathname+filesep()+'4_8_data.sci'
exec(filename)

// Solution:
// velocity through steel pipes,
v=(Q/449)/((%pi*((D/12)^2))/4); //ft/s
// rounding off the above answer
v=fix(v)+(fix(floor((v-fix(v))*10))/10); //ft/s
// Reynolds Number,
N_R=(7740*v*D)/nu;
// friction factor,
f=64/N_R;
// From table of "K factors of common valves and
    fittings",
K=10;
// Equivalent Length,
Le=(K*(D_1/12))/f; //ft

// Results:
printf("\n  Results:  ")
printf("\n The Equivalent Length of Globe valve is %
    .1f ft.",Le)
```

Scilab code Exa 4.9.a find pressure at inlet of hydraulicmotor

```
// Aim:Refer Example 4-9 for Problem Description
// Given:
// Pump hydraulic power:
HHP=5; //HP
// Pump flow:
Q=30; //gpm
// Inside Diameter of pipe:
D=1; //in
// specific gravity of oil:
SG_oil=0.9;
// Kinematic viscosity of oil:
nu=100; //cS
// elevation between station 1 and 2:
Z=-20; //ft ,-ve sign indicates station 2 is above
    Station 1
// Pressure at oil top surface level in hydraulic
    tank:
p1=0; //psig
```

Scilab code Exa 4.9.b SOLUTION pressure at inlet of hydraulicmotor

```
clc;
pathname=get_absolute_file_path('4_9_soln.sce')
filename=pathname+filesep()+'4_9_data.sci'
exec(filename)

// Solution:
// specific weight of oil,
gamma1=SG_oil*62.4; //lb/ft^3
```

```
// acceleration due to gravity,
g=32.2; //ft/s^2
// Since, There is no hydraulic motor,
Hm=0; //ft
// oil in tank is at rest,
v1=0; //ft/s
// velocity head at station 1,
K1=(v1^2)/(2*g); //ft
// velocity through pipe,
v2=(Q/449)/((%pi*((D/12)^2))/4); //ft/s
v2=fix(v2)+(fix(floor((v2-fix(v2))*10))/10); //ft/s
    ,rounding off the answer
// velocity head at station 2,
K2=(v2^2)/(2*g); //ft
K2=fix(K2)+(fix(ceil((K2-fix(K2))*10))/10); //ft ,
    rounding off the answer
// Reynolds Number,
N_R=round((7740*v2*D)/nu);
// friction factor,
f=64/N_R;
// From table of "K factors of common valves and
    fittings",
K=0.9;
// equivalent length of standard elbow,
Le_std_elbow=((K*(D/12))/f); //ft
// Total equivalent length,
Le_tot=21+Le_std_elbow; //ft
// head loss due to friction between Station 1 and
    2,
H_L=round((f*Le_tot*K2)/(D/12)); //ft
// Pump head,
Hp=ceil((3950*HHP)/(Q*SG_oil)); //ft
// Pressure at station 2,
p2=round(Z+(p1/gamma1)+K1+Hp-Hm-H_L-K2); //ft ,
    Modified Bernoulli equation
p2=round((p2*gamma1)/144); //psi
// Pressure increase across the pump,
delp=ceil((gamma1*Hp)/144);
```

```

// Results:
printf("\n  Results:  ")
printf("\n The Pressure available at the inlet to
    hydraulic motor is %.0f psi.",p2)
```

Scilab code Exa 4.10.a find pressure inlet hydraulic motor SI

```
// Aim:Refer Example 4-10 for Problem Description
// Given:
// Pump hydraulic power:
HHP=3.73; //kW
// Pump flow:
Q=0.00190; //m^3/s
// Inside Diameter of pipe:
D=0.0254; //m
// specific gravity of oil:
SG_oil=0.9;
// Kinematic viscosity of oil:
nu=100; //cS
// elevation between station 1 and 2:
Z=-6.10; //m ,-ve sign indicates station 2 is above
    Station 1
// Pressure at oil top surface level in hydraulic
    tank:
p1=0; //Pa
// Pump inlet pipe length:
L1=1.53; //m
// Pump outlet pipe length up to hydraulic motor:
L2=4.88; //m
```

Scilab code Exa 4.10.b SOLUTION pressure inlet hydraulic motor SI

```
clc;
pathname=get_absolute_file_path('4_10_soln.sce')
filename=pathname+filesep()+'4_10_data.sci'
exec(filename)

// Solution:
// specific weight of oil,
gamma1=SG_oil*9800; //N/m^3
// acceleration due to gravity,
g=9.80; //m/s^2
// Since, There is no hydraulic motor,
Hm=0; //m
// oil in tank is at rest,
v1=0; //m/s
// velocity head at station 1,
K1=(v1^2)/(2*g); //m
// velocity through pipe,
v2=Q/((%pi*(D^2))/4); //m/s
// velocity head at station 2,
K2=(v2^2)/(2*g); //m
// Reynolds Number,
N_R=((v2*D)/(nu/1000000));
// friction factor,
f=64/N_R;
// From table of "K factors of common valves and fittings",
K=0.9;
// equivalent length of standard elbow,
Le_std_elbow=((K*(D/12))/f); //m
// Total equivalent length,
Le_tot=L1+L2+Le_std_elbow; //m
// head loss due to friction between Station 1 and 2,
H_L=((f*Le_tot*K2)/D); //m
// Pump head,
Hp=((1000*HHP)/(Q*gamma1)); //m
// Pressure at station 2,
p2=(Z+(p1/gamma1)+K1+Hp-Hm-H_L-K2); //m ,Modified
```

```
   Bernoulli equation
p2=((p2*gamma1)/1000); //kPa

// Results:
printf("\n  Results:  ")
printf("\n The Pressure available at the inlet to hydraulic motor is %.0f kPa.",p2)
printf("\n The answer in the program is different than that in textbook. It may be due to no.s of significant digit in data and calculation")
```

Chapter 5

HYDRAULIC PUMPS

Scilab code Exa 5.1.a find volumetric efficiency of gear pump

```
// Aim:To Find volumetric efficiency of Gear Pump
// Given:
// outside diameter of gear pump:
Do=3; //in
// inside diameter of gear pump:
Di=2; //in
// width of gear pump:
L=1; //in
// Actual flow rate of pump:
Qa=28; //gpm
// Speed of gear pump:
N=1800; //rpm
```

Scilab code Exa 5.1.b SOLUTION volumetric efficiency of gear pump

```
clc;
pathname=get_absolute_file_path('5_1_soln.sce')
filename=pathname+filesep()+'5_1_data.sci'
```

```
exec(filename)

// Solutions:
// Volumetric Displacementis is given by,
Vd=(%pi/4)*((Do^2)-(Di^2))*L; //in^3
// Theoretical Flow rate,
Qt=(Vd*N)/231; //gpm
// Volumetric efficiency ,
eta_v=(Qa/Qt)*100; //%

// Results:
printf("\n  Results:  ")
printf("\n The volumetric efficiency of Gear Pump
   is %.1f percent.",eta_v)
printf("\n The answer in the program is different
   than that in textbook. It may be due to no.s of
   significant digit in data and calculation")
```

Scilab code Exa 5.2.a find actual flowrate of gear pump

```
// Aim:To Find actual flow-rate of Gear Pump
// Given:
// outside diameter of gear pump:
Do=75; //mm
// inside diameter of gear pump:
Di=50; //mm
// width of gear pump:
L=25; //mm
// Volumetric efficiency ,
eta_v=90; //%
// Speed of gear pump:
N=1000; //rpm
```

Scilab code Exa 5.2.b SOLUTION actual flowrate of gear pump

```
clc;
pathname=get_absolute_file_path('5_2_soln.sce')
filename=pathname+filesep()+'5_2_data.sci'
exec(filename)

// Solutions:
// Volumetric Displacementis is given by,
Vd=(%pi/4)*(((Do/1000)^2)-((Di/1000)^2))*(L/1000);
    //m^3/rev
// Actual Flow-rate,
Qa=Vd*N*(eta_v/100); //m^3/min
Qa_lpm=Qa*1000; //Lpm
// rounding off the above answer
Qa_lpm=fix(Qa_lpm)+(fix(ceil((Qa_lpm-fix(Qa_lpm))
    *10))/10); //m^3/min

// Results:
printf("\n  Results:  ")
printf("\n The volumetric efficiency of Gear Pump
    is %.1f Lpm.",Qa_lpm)
```

Scilab code Exa 5.3.a find eccentricity of vane pump

```
// Aim:To Find eccentricity of Vane Pump
// Given:
// volumetric displacement of vane pump:
Vd=5; //in^3
// rotor diameter of vane pump:
Dr=2; //in
// cam ring diameter of vane pump:
Dc=3; //in
// width of vane:
L=2; //in
```

Scilab code Exa 5.3.b SOLUTION eccentricity of vane pump

```
clc;
pathname=get_absolute_file_path('5_3_soln.sce')
filename=pathname+filesep()+'5_3_data.sci'
exec(filename)

// Solutions:
// eccentricity for vane pump,
e=2*Vd/(%pi*(Dc+Dr)*L); //in

// Results:
printf("\n  Results:  ")
printf("\n The eccentricity of vane pump  is %.3f in
    .",e)
```

Scilab code Exa 5.4.a find volumetric displacement of vane pump

```
// Aim:To Find volumetric displacement of Vane Pump
// Given:
// rotor diameter of vane pump:
Dr=50; //mm
// cam ring diameter of vane pump:
Dc=75; //mm
// width of vane:
L=50; //mm
// eccentricity:
e=8; //mm
```

Scilab code Exa 5.4.b SOLUTION volumetric displacement of vane pump

```
clc;
pathname=get_absolute_file_path('5_4_soln.sce')
filename=pathname+filesep()+'5_4_data.sci'
exec(filename)

// Solutions:
// volumetric displacement of pump,
Vd=(%pi*((Dc/1000)+(Dr/1000))*(e/1000)*(L/1000))/2;
    //m^3
// since,1m^3 = 1000L
Vd=1000*Vd; //L

// Results:
printf("\n  Results:  ")
printf("\n The volumetric displacement of vane pump
    is %.4f L.",Vd)
```

Scilab code Exa 5.5.a find power pres compensated pump saved

```
// Aim:Refer Example 5-5 for Problem Description
// Given:
// for Fixed Displacement pump:
// pump delivery pressure:
Pd_f=1000; //psi
// pump flow rate:
Q_f=20; //gpm
// oil leakge after cylinder is fully extended:
Ql_f=0.7; //gpm
// pressure relief valve setting:
p=1200; //psi

// for Pressure Compensated pump:
// pump flow rate:
```

```
Q_p=0.7; //gpm
// pressure relief valve setting:
P=1200; //psi
```

Scilab code Exa 5.5.b SOLUTION power pres compensated pump saved

```
clc;
pathname=get_absolute_file_path('5_5_soln.sce')
filename=pathname+filesep()+'5_5_data.sci'
exec(filename)

// Solutions:
// Hydraulic Power lost in Fixed Displacemnt pump,
HP_f=(p*Q_f)/1714; //HP
// Hydraulic Power lost in Pressure Compensated pump
   ,
HP_p=(P*Q_p)/1714; //HP
// Therefore, Hydraulic Power saved,
HP=HP_f-HP_p; //HP

// Results:
printf("\n  Results:  ")
printf("\n The Hydraulic Power saved after cylinder
   is fully extended is %.2f HP.",HP)
```

Scilab code Exa 5.6.a find offset angle of piston pump

```
// Aim:To Find offset angle of axial piston pump
// Given:
// pump flow rate:
Qa=16; //gpm
// speed of pump:
N=3000; //rpm
```

```
// number of pistons:
Y=9;
// piston diameter:
d=0.5; //in
// piston circle diameter:
D=5; //in
// volumetric efficiency:
eta_v=95; //%
```

Scilab code Exa 5.6.b SOLUTION offset angle of piston pump

```
clc;
pathname=get_absolute_file_path('5_6_soln.sce')
filename=pathname+filesep()+'5_6_data.sci'
exec(filename)

// Solutions:
// Theoretical flow rate,
Qt=Qa/(eta_v/100); //gpm
// Area of piston,
A=(%pi/4)*(d^2); //in^2
// tan of offset angle,
T_theta=(231*Qt)/(D*A*N*Y);
// offset angle,
theta=atand(T_theta); //deg

// Results:
printf("\n  Results:  ")
printf("\n The offset angle of axial piston pump is
   %.1f deg.",theta)
```

Scilab code Exa 5.7.a find flowrate of axial piston pump

```
// Aim:To Find flow rate of axial piston pump in L/s
// Given:
// speed of pump:
N=1000; //rpm
// number of pistons:
Y=9;
// piston diameter:
d=15; //mm
// piston circle diameter:
D=125; //mm
// offset angle:
theta=10; //deg
// volumetric efficiency:
eta_v=94; //%
```

Scilab code Exa 5.7.b SOLUTION flowrate of axial piston pump

```
clc;
pathname=get_absolute_file_path('5_7_soln.sce')
filename=pathname+filesep()+'5_7_data.sci'
exec(filename)

// Solutions:
// Area of piston,
A=(%pi/4)*((d/1000)^2); //m^2
// offset angle,
theta=(theta*%pi)/180; //rad
// Theoretical flow rate,
Qt=(D/1000)*A*N*Y*tan(theta); //m^3/min
// Actual flow rate,
Qa=Qt*(eta_v/100); //m^3/min
// rounding off the above answer
Qa=fix(Qa)+(fix(round((Qa-fix(Qa))*1000))/1000); //m
    ^3/min
// Actual flow rate in L/s,
```

```
Qa=Qa/(60*0.001); //L/s

// Results:
printf("\n  Results:  ")
printf("\n The flow rate of axial piston pump in L/s
    is %.3f L/s.",Qa)
```

Scilab code Exa 5.8.a find theoretical torque required by pump

```
// Aim:Refer Example 5-8 for Problem Description
// Given:
// Displacement volume:
Vd=5; //in^3
// Actual pump flow rate:
Qa=20; //gpm
// Speed of the pump:
N=1000; //rpm
// Pressure delivered by pump:
p=1000; //psi
// Prime mover input torque:
Ta=900; //in.lb
```

Scilab code Exa 5.8.b SOLUTION theoretical torque required by pump

```
clc;
pathname=get_absolute_file_path('5_8_soln.sce')
filename=pathname+filesep()+'5_8_data.sci'
exec(filename)

// Solutions:
// Theoretical pump flow rate,
Qt=(Vd*N)/231; //gpm
// rounding off the above answer
```

```
Qt=fix(Qt)+(fix(floor((Qt-fix(Qt))*10))/10); //gpm
// Therefore,volumetric efficiency,
eta_v=(Qa/Qt);
// Now, mechanical efficiency,
eta_m=((p*Qt)/1714)/((Ta*N)/63000);
// overall Efficiency,
eta_o=eta_v*eta_m*100; //%
// rounding off the above answer
eta_o=fix(eta_o)+(fix(floor((eta_o-fix(eta_o))*10))
    /10); //%
// Theoretical torque required to operate the pump,
Tt=floor(eta_m*Ta); //in.lb

// Results:
printf("\n  Results:  ")
printf("\n The overall efficiency of pump is %.1f
    percent.",eta_o)
printf("\n The Theoretical torque required to
    operate the pump  is %.0f in.lb.",Tt)
```

Scilab code Exa 5.9.a find theoretical torque required in SI

```
// Aim:Refer Example 5-9 for Problem Description
// Given:
// Displacement volume:
Vd=100; //cm^3
// Actual pump flow rate:
Qa=0.0015; //m^3/s
// Speed of the pump:
N=1000; //rpm
// Pressure delivered by pump:
p=70; //bars
// Prime mover input torque:
Ta=120; //N.m
```

Scilab code Exa 5.9.b SOLUTION theoretical torque required in SI

```
clc;
pathname=get_absolute_file_path('5_9_soln.sce')
filename=pathname+filesep()+'5_9_data.sci'
exec(filename)

// Solutions:
// volumetric displacement in m^3/rev,
Vd=100/(10^6); //m^3/rev
// Speed of pump in rps,
N=N/60; //rps
// Theoretical pump flow rate,
Qt=Vd*N; //m^3/s
// Therefore,volumetric efficiency,
eta_v=(Qa/Qt);
// Now, mechanical efficiency,
eta_m=(p*10^5*Qt)/(Ta*N*2*(%pi));
// overall Efficiency,
eta_o=eta_v*eta_m*100; //%
// rounding off the above answer
eta_o=fix(eta_o)+(fix(floor((eta_o-fix(eta_o))*10))
    /10); //%
// Theoretical torque required to operate the pump,
Tt=ceil(eta_m*Ta); //N.m

// Results:
printf("\n  Results:  ")
printf("\n The overall efficiency of pump is %.1f
    percent.",eta_o)
printf("\n The Theoretical torque required to
    operate the pump  is %.0f N.m.",Tt)
```

Scilab code Exa 5.10.a find yearly cost of electricity

```
// Aim:Refer Example 5-10 for Problem Description
// Given:
// Speed of the pump:
N=1000; //rpm
// Prime mover input torque:
Ta=120; //N.m
// overall efficiency:
eta_o=85; //%
// operation time= 12 hrs/day for 250 days/year:
OT=12*250; //hrs/yr
// cost of electricity:
coe=0.11; //$/kW.hr
// overall efficiency for pump:
eta_l=83.5; //%
```

Scilab code Exa 5.10.b SOLUTION yearly cost of electricity

```
clc;
pathname=get_absolute_file_path('5_10_soln.sce')
filename=pathname+filesep()+'5_10_data.sci'
exec(filename)

// Solutions:
// Pump input power,
IP=Ta*N/9550; //kW
// Electric motor input power,
EIP=IP/(eta_o/100); //kW
// rounding off the above answer
EIP=fix(EIP)+(fix(round((EIP-fix(EIP))*10))/10); //
    kW
```

```
// Yearly cost of electricity,
Yce=EIP*OT*coe; //$/yr
// Total kW loss,
kWL=((1-(eta_o/100))*EIP)+((1-(eta_l/100))*IP); //kW
// rounding off the above answer
kWL=fix(kWL)+(fix(round((kWL-fix(kWL))*10))/10); //kW
// Yearly cost due to inefficiencies,
Yci=(kWL/EIP)*Yce; //$/yr

// Results:
printf("\n  Results:  ")
printf("\n The yearly cost of electricity is %.0f $/yr.",Yce)
printf("\n The yearly cost of electricity due to inefficiencies is %.0f $/yr.",Yci)
```

Chapter 6

HYDRAULIC CYLINDERS AND CUSHIONING DEVICES

Scilab code Exa 6.1.a find pressure velocity and horsepower

```
// Aim:Refer Example 6-1 for Problem Description
// Given:
// Flow rate of pump:
Q_in=20; //gpm
// Bore diameter of Cylinder:
D=2; //in
// Load during extending and retracting:
F_ext=1000; //lb
F_ret=1000; //lb
// Rod diameter of cylinder:
d=1; //in
```

Scilab code Exa 6.1.b SOLUTION pressure velocity and horsepower

```
clc;
pathname=get_absolute_file_path('6_1_soln.sce')
filename=pathname+filesep()+'6_1_data.sci'
exec(filename)

// Solution:
// Area of blank end of piston,
Ap=(%pi/4)*(D^2); //in^2
// Area of rod end of piston,
Ar=(%pi/4)*(d^2); //in^2
// hydraulic pressure during the extending stroke,
p_ext=F_ext/Ap; //psi
// piston velocity during the extending stroke,
v_ext=(Q_in/449)/(Ap/144); //ft/s
// rounding off the above answer
v_ext=fix(v_ext)+(fix(ceil((v_ext-fix(v_ext))*100))/100); //ft/s
// cylinder horsepower during the extending stroke,
HP_ext=(v_ext*F_ext)/550; //HP
// rounding off the above answer
HP_ext=fix(HP_ext)+(fix(floor((HP_ext-fix(HP_ext))*100))/100); //HP
// hydraulic pressure during the retraction stroke,
p_ret=ceil(F_ret/(Ap-Ar)); //psi
// piston velocity during the retraction stroke,
v_ret=(Q_in/449)/((Ap-Ar)/144); //ft/s;
// rounding off the above answer
v_ret=fix(v_ret)+(fix(ceil((v_ret-fix(v_ret))*100))/100); //ft/s
// cylinder horsepower during the retraction stroke,
HP_ret=(v_ret*F_ret)/550; //HP

// Results:
printf("\n  Results:  ")
printf("\n The hydraulic pressure during the extending stroke is %.0f psi.",p_ext)
printf("\n The piston velocity during the extending stroke is %.2f ft/s.",v_ext)
```

```
printf("\n The cylinder horsepower during the
    extending stroke is %.2f HP.",HP_ext)
printf("\n The hydraulic pressure during the
    retraction stroke is %.0f psi.",p_ret)
printf("\n The piston velocity during the retraction
    stroke is %.2f ft/s.",v_ret)
printf("\n The cylinder horsepower during the
    retraction stroke is %.2f HP.",HP_ret)
```

Scilab code Exa 6.2.a find cylinder force to move 6000lb

```
// Aim:Refer Example 6-2 for Problem Description
// Given:
// Weight of Body:
W=6000; //lb
// coefficient of friction between weight and
    horizontal support:
CF=0.14;
```

Scilab code Exa 6.2.b SOLUTION cylinder force to move 6000lb

```
clc;
pathname=get_absolute_file_path('6_2_soln.sce')
filename=pathname+filesep()+'6_2_data.sci'
exec(filename)

// Solution:
// Cylinder Force,
F=CF*W; //lb

// Results:
printf("\n  Results:  ")
```

```
printf("\n The Cylinder Force at constant velocity
    is %.0f lb.",F)
```

Scilab code Exa 6.3.a find force to move inclined weight

```
// Aim:Refer Example 6-3 for Problem Description
// Given:
// Weight of Body:
W=6000; //lb
// Inclination of Weight:
theta=30; //deg
```

Scilab code Exa 6.3.b SOLUTION force to move inclined weight

```
clc;
pathname=get_absolute_file_path('6_3_soln.sce')
filename=pathname+filesep()+'6_3_data.sci'
exec(filename)

// Solution:
// Inclination of Weight,
theta=(theta*%pi)/180; //rad
// Cylinder Force,
F=W*sin(theta); //lb

// Results:
printf("\n  Results:  ")
printf("\n The Cylinder Force at constant velocity
    is %.0f lb.",F)
```

Scilab code Exa 6.4.a find cylinder force to accelerate weight

```
// Aim:Refer Example 6-4 for Problem Description
// Given:
// Weight of Body:
W=6000; //lb
// initial velocity:
u=0; //ft/s
// final velocity:
v=8; //ft/s
// Time taken:
t=0.5; //s
```

Scilab code Exa 6.4.b SOLUTION cylinder force to accelerate weight

```
clc;
pathname=get_absolute_file_path('6_4_soln.sce')
filename=pathname+filesep()+'6_4_data.sci'
exec(filename)

// Solution:
// For constant velocity,Cylinder Force,
F=W; //lb
// Rate of change of velocity,
a=(v-u)/t; //ft/s^2
// Force required to accelerate the weight,
F_acc=(F/32.2)*a; //lb
// Therefore, Cylinder Force,
F_cyl=(F+F_acc); //lb

// Results:
printf("\n  Results:  ")
printf("\n The Cylinder Force at constant velocity
   is %.0f lb.",F)
printf("\n The Cylinder Force required to accelerate
```

```
    the Body is %.0f lb.",F_cyl)
printf("\n The answer in the program is different
    than that in textbook. It may be due to no.s of
    significant digit in data and calculation")
```

Scilab code Exa 6.5.a find cylinder force using lever system

```
// Aim:Refer Example 6-5 for Problem Description
// Given:
L1=10; //in
L2=10; //in
// Inclination of cylinder axis with vertical axis:
phi=0; //deg
// cylinder load:
F_load=1000; //lb
```

Scilab code Exa 6.5.b SOLUTION cylinder force using lever system

```
clc;
pathname=get_absolute_file_path('6_5_soln.sce')
filename=pathname+filesep()+'6_5_data.sci'
exec(filename)

// Solution:
// Inclination of cylinder axis with vertical axis,
phi=(phi*%pi)/180; //rad
// cylinder force required to overcome load using
    First Class Lever Sytem,
F_cyl_1=(L2*F_load)/(L1*cos(phi)); //lb
// cylinder force required to overcome load using
    Second Class Lever Sytem,
F_cyl_2=(L2*F_load)/((L1+L2)*cos(phi)); //lb
```

```
// cylinder force required to overcome load using
   Third Class Lever Sytem,
F_cyl_3=((L1+L2)*F_load)/(L2*cos(phi)); //lb

// Results:
printf("\n  Results:  ")
printf("\n The Cylinder Force using First Class
   lever System is %.0f lb.",F_cyl_1)
printf("\n The Cylinder Force using Second Class
   lever System is %.0f lb.",F_cyl_2)
printf("\n The Cylinder Force using Third Class
   lever System is %.0f lb.",F_cyl_3)
```

Scilab code Exa 6.6.a find maximum pressure developed by cushion

```
// Aim:Refer Example 6-6 for Problem Description
// Given:
// Flow rate of pump:
Q_pump=18.2; //gpm
// Diameter of blank end of piston:
D=3; //in
// Diameter of cushion plunger:
D_cush=1; //in
// Stroke of cushion plunger:
L_cush=0.75; //in
// Distance Piston decelerates at the end of
   extending stroke:
L=0.75; //in
// Weight of Body:
W=1500; //lb
// coefficient of friction:
CF=0.12;
// Pressure relief valve settings:
p_relf=750; //psi
// maximum pressure at the Blank end:
```

```
p1=750; //psi
```

Scilab code Exa 6.6.b SOLUTION maximum pressure developed by cushion

```
clc;
pathname=get_absolute_file_path('6_6_soln.sce')
filename=pathname+filesep()+'6_6_data.sci'
exec(filename)

// Solution:
// Area of blank end of piston,
A_piston=(%pi/4)*(D^2); //in^2
// piston velocity prior to deceleration,
v=(Q_pump/449)/(A_piston/144); //ft/s
// deceleration of piston at the end of extending stroke,
a=(v^2)/(2*(L/12)); //ft/s^2
// Area of cushion plunger,
A_cush=(%pi/4)*(D_cush^2); //in^2
// maximum pressure developed by the cushion,
p2=(((W*a)/32.2)+(p1*A_piston)-(CF*W))/(A_piston-A_cush); //psi

// Results:
printf("\n  Results:  ")
printf("\n The maximum pressure developed by the cushion is %.0f psi.",p2)
```

Chapter 7

HYDRAULIC MOTORS

Scilab code Exa 7.1.a find pressure developed to overcome load

```
// Aim:To determine pressure developed to overcome
   load
// Given:
// outer radius of rotor:
R_R=0.5; //in
// outer radius of vane:
R_V=1.5; //in
// width of vane:
L=1; //in
// Torque Load:
T=1000; //in.lb
```

Scilab code Exa 7.1.b SOLUTION pressure developed to overcome load

```
clc;
pathname=get_absolute_file_path('7_1_soln.sce')
filename=pathname+filesep()+'7_1_data.sci'
exec(filename)
```

```

// Solution:
// volumetric displacement,
V_D=%pi*((R_V^2)-(R_R^2))*L; //in^3
// pressure developed to overcome load,
p=2*%pi*T/V_D; //psi

// Results:
printf("\n  Results:  ")
printf("\n The pressure developed to overcome load
    is %.0f psi.",p)
```

Scilab code Exa 7.2.a determine theoretical horsepower of hydraulic motor

```
// Aim:Refer Example 7-2 for Problem Description
// Given:
// volumetric displacement:
V_D=5; //in^3
// pressure rating:
p=1000; //psi
// theoretical flow-rate of pump:
Q_T=10; //gpm
```

Scilab code Exa 7.2.b SOLUTION theoretical horsepower of hydraulic motor

```
clc;
pathname=get_absolute_file_path('7_2_soln.sce')
filename=pathname+filesep()+'7_2_data.sci'
exec(filename)

// Solution:
```

```
// motor speed,
N=231*Q_T/V_D; //rpm
// Theoretical torque,
T_T=floor(V_D*p/(2*%pi)); //in.lb
// Theoretical horsepower,
HP_T=T_T*N/63000; //HP

// Results:
printf("\n  Results:  ")
printf("\n The motor Speed is %.0f rpm.",N)
printf("\n The motor Theoretical torque is %.0f in.
    lb.",T_T)
printf("\n The motor Theoretical horsepower is %.2f
    HP.",HP_T)
```

Scilab code Exa 7.3.a find actual horsepower delivered by motor

```
// Aim:Refer Example 7-3 for Problem Description
// Given:
// volumetric displacement:
V_D=10; //in^3
// pressure rating:
p=1000; //psi
// speed of motor:
N=2000; //rpm
// actual flow-rate of motor:
Q_A=95; //gpm
// actual torque delivered by motor:
T_A=1500; //in.lb
```

Scilab code Exa 7.3.b SOLUTION actual horsepower delivered by motor

```
clc;
```

```
pathname=get_absolute_file_path('7_3_soln.sce')
filename=pathname+filesep()+'7_3_data.sci'
exec(filename)

// Solution:
// theoretical flow-rate,
Q_T=V_D*N/231; //gpm
// volumetric efficiency,
eta_v=(Q_T/Q_A)*100; //%
// theoretical torque,
T_T=(V_D*p/(2*%pi)); //in.lb
// mechanical efficiency,
eta_m=(T_A/T_T)*100; //%
// overall efficiency,
eta_o=(eta_v/100)*(eta_m/100)*100; //%
eta_o=fix(eta_o)+(fix(floor((eta_o-fix(eta_o))*10))
    /10); //% ,rounding off the answer
// actual horsepower delivered by motor,
HP_A=T_A*N/63000; //HP

// Results:
printf("\n  Results:  ")
printf("\n The volumetric efficiency is %.1f percent
    .",eta_v)
printf("\n The mechanical efficiency is %.1f percent
    .",eta_m)
printf("\n The overall efficiency is %.1f percent.",
    eta_o)
printf("\n The actual horsepower delivered by the
    motor is %.1f HP.",HP_A)
```

Scilab code Exa 7.4.a find motor displacement and output torque

```
// Aim:Refer Example 7-4 for Problem Description
// Given:
```

```
// operating pressure:
p=1000; //psi
// volumetric displacement of pump:
V_D_pump=5; //in^3
// speed of pump:
N_pump=500; //rpm
// volumetric efficiency of pump:
eta_v_pump=82; //%
// mechanical efficiency of pump:
eta_m_pump=88; //%
// speed of motor:
N_motor=400; //rpm
// volumetric efficiency of motor:
eta_v_motor=92; //%
// mechanical efficiency of motor:
eta_m_motor=90; //%
```

Scilab code Exa 7.4.b SOLUTION motor displacement and output torque

```
clc;
pathname=get_absolute_file_path('7_4_soln.sce')
filename=pathname+filesep()+'7_4_data.sci'
exec(filename)

// Solution:
// pump theoretical flow-rate,
Q_T_pump=V_D_pump*N_pump/231; //gpm
// pump actual flow rate,
Q_A_pump=Q_T_pump*(eta_v_pump/100); //gpm
// motor theoretical flow-rate,
Q_T_motor=Q_A_pump*(eta_v_motor/100); //gpm ,motor
    actual flow-rate = pump actual flow rate
// motor displacement,
V_D_motor=Q_T_motor*231/N_motor; //in^3
// hydraulic HP delivered to motor,
```

```
HHP_motor=p*Q_A_pump/1714; //HP
// brake HP delivered by motor,
BHP_motor=HHP_motor*(eta_v_motor/100)*(eta_m_motor/100); //HP
BHP_motor=fix(BHP_motor)+(fix(floor((BHP_motor-fix(BHP_motor))*100))/100); //HP ,rounding off the answer
// torque delivered by motor,
T_motor=(BHP_motor*63000/N_motor); //in.lb

// Results:
printf("\n  Results:  ")
printf("\n The Displacement of motor is %.2f in^3.",V_D_motor)
printf("\n The Motor output torque is %.0f in.lb.",T_motor)
```

Scilab code Exa 7.5.a find motor theoretical power in SI

```
// Aim:Refer Example 7-5 for Problem Description
// Given:
// volumetric displacement:
V_D=0.082; //L
// pressure rating:
p=70; //bar
// theoretical flow-rate of pump:
Q_T=0.0006; //m^3/s
```

Scilab code Exa 7.5.b SOLUTION motor theoretical power in SI

```
clc;
pathname=get_absolute_file_path('7_5_soln.sce')
filename=pathname+filesep()+'7_5_data.sci'
```

```
exec(filename)

// Solution:
// motor speed,
N=(Q_T*60)/(V_D*10^-3); //rpm
// Theoretical torque,
T_T=((V_D*10^-3)*(p*10^5))/(2*%pi); //Nm
// Theoretical power,
HP_T=T_T*N*2*%pi/(60*1000); //kW

// Results:
printf("\n  Results:  ")
printf("\n The motor Speed is %.0f rpm.",N)
printf("\n The motor Theoretical torque is %.1f Nm."
   ,T_T)
printf("\n The motor Theoretical power is %.2f kW.",
   HP_T)
```

Scilab code Exa 7.6.a find actual KW delivered by motor

```
// Aim:Refer Example 7-6 for Problem Description
// Given:
// volumetric displacement:
V_D=164; //cm^3
// pressure rating:
p=70; //bar
// speed of motor:
N=2000; //rpm
// actual flow-rate of motor:
Q_A=0.006; //m^3/s
// actual torque delivered by motor:
T_A=170; //Nm
```

Scilab code Exa 7.6.b SOLUTION actual KW delivered by motor

```
clc;
pathname=get_absolute_file_path('7_6_soln.sce')
filename=pathname+filesep()+'7_6_data.sci'
exec(filename)

// Solution:
// theoretical flow-rate,
Q_T=(V_D*10^-6)*(N/60); //m^3/s
Q_T=fix(Q_T)+(fix(ceil((Q_T-fix(Q_T))*10^5))/10^5);
    //m^3/s ,rounding off the answer
// volumetric efficiency,
eta_v=(Q_T/Q_A)*100; //%
// theoretical torque,
T_T=((V_D*10^-6)*(p*10^5))/(2*%pi); //Nm
// mechanical efficiency,
eta_m=(T_A/T_T)*100; //%
// overall efficiency,
eta_o=(eta_v/100)*(eta_m/100)*100; //%
eta_o=fix(eta_o)+(fix(floor((eta_o-fix(eta_o))*10))
    /10); //% ,rounding off the answer
// actual horsepower delivered by motor,
HP_A=(T_A*N*2*%pi)/(60*1000); //kW

// Results:
printf("\n  Results:  ")
printf("\n The volumetric efficiency is %.1f percent
    .",eta_v)
printf("\n The mechanical efficiency is %.1f percent
    .",eta_m)
printf("\n The overall efficiency is %.1f percent.",
    eta_o)
printf("\n The actual horsepower delivered by the
    motor is %.1f kW.",HP_A)
```

Scilab code Exa 7.7.a find motor output torque in SI

```
// Aim:Refer Example 7-7 for Problem Description
// Given:
// operating pressure:
p=70; //bar
// volumetric displacement of pump:
V_D_pump=82; //cm^3
// speed of pump:
N_pump=500; //rpm
// volumetric efficiency of pump:
eta_v_pump=82; //%
// mechanical efficiency of pump:
eta_m_pump=88; //%
// speed of motor:
N_motor=400; //rpm
// volumetric efficiency of motor:
eta_v_motor=92; //%
// mechanical efficiency of motor:
eta_m_motor=90; //%
```

Scilab code Exa 7.7.b SOLUTION motor output torque in SI

```
clc;
pathname=get_absolute_file_path('7_7_soln.sce')
filename=pathname+filesep()+'7_7_data.sci'
exec(filename)

// Solution:
// pump theoretical flow-rate,
Q_T_pump=(V_D_pump*10^-6)*(N_pump/60); //m^3/s
// pump actual flow rate,
```

```
Q_A_pump=Q_T_pump*(eta_v_pump/100); //m^3/s
// motor theoretical flow-rate,
Q_T_motor=Q_A_pump*(eta_v_motor/100); //m^3/s ,motor actual flow-rate = pump actual-flow rate
// motor displacement,
V_D_motor=(Q_T_motor/(N_motor/60))*10^6; //cm^3
// hydraulic HP delivered to motor,
HHP_motor=(p*10^5)*Q_A_pump; //W
// brake HP delivered by motor,
BHP_motor=HHP_motor*(eta_v_motor/100)*(eta_m_motor/100); //W
BHP_motor=fix(BHP_motor)+(fix(floor((BHP_motor-fix(BHP_motor))*100))/100); //W ,rounding off the answer
// torque delivered by motor,
T_motor=(BHP_motor/N_motor)*(60/(2*%pi)); //Nm

// Results:
printf("\n  Results:  ")
printf("\n The Displacement of motor is %.1f cm^3.",V_D_motor)
printf("\n The Motor output torque is %.1f Nm.",T_motor)
```

Chapter 8

HYDRAULIC VALVES

Scilab code Exa 8.1.a determine cracking and full flow pressure

```
// Aim:Refer Example 8-1 for Problem Description
// Given:
// area of relief valve:
A=0.75; //in^2
// spring constant:
k=2500; //lb/in
// initial compressed length of spring:
S=0.20; //in
// poppet displacement to pass full pump flow:
L=0.10; //in
```

Scilab code Exa 8.1.b SOLUTION cracking and full flow pressure

```
clc;
pathname=get_absolute_file_path('8_1_soln.sce')
filename=pathname+filesep()+'8_1_data.sci'
exec(filename)

```

```
// Solution:
// spring force excerted on poppet when it is fully closed,
F=k*S; //lb
// Cracking pressure,
p_crack=F/A; //psi
// spring force when poppet moves 0.10 in from its fully closed position,
F_new=k*(L+S); //lb
// Full pump flow pressure,
p_ful_pump_flow=F_new/A; //psi

// Results:
printf("\n  Results:  ")
printf("\n The Cracking pressure is %.0f psi.",p_crack)
printf("\n The Full pump flow pressure  is %.0f psi.",p_ful_pump_flow)
```

Scilab code Exa 8.2.a compute horsepower across pressure relief valve

```
// Aim:To compute horsepower across the pressure relief valve
// Given:
// pressure relief valve setting:
p=1000; //psi
// pump flow to the tank:
Q=20; //gpm
```

Scilab code Exa 8.2.b SOLUTION horsepower across pressure relief valve

```
clc;
pathname=get_absolute_file_path('8_2_soln.sce')
```

```
filename=pathname+filesep()+'8_2_data.sci'
exec(filename)

// Solution:
// Horsepower across the valve,
HP=((p*Q)/1714); //HP

// Results:
printf("\n  Results:  ")
printf("\n The Horsepower across the pressure relief
    valve is %.1f HP.",HP)
```

Scilab code Exa 8.3.a compute horsepower across unloading valve

```
// Aim:To compute horsepower across the unloading
   valve
// Given:
// pump pressure during unloading:
p=25; //psi
// pump flow to the tank:
Q=20; //gpm
```

Scilab code Exa 8.3.b SOLUTION horsepower across unloading valve

```
clc;
pathname=get_absolute_file_path('8_3_soln.sce')
filename=pathname+filesep()+'8_3_data.sci'
exec(filename)

// Solution:
// Horsepower across the valve,
HP=((p*Q)/1714); //HP

```

```
// Results:
printf("\n  Results:  ")
printf("\n The Horsepower across the unloading valve
    is %.2f HP.",HP)
```

Scilab code Exa 8.4.a find flow rate through the orifice

```
// Aim:To find flow-rate through given orifice
// Given:
// pressure drop across orifice:
del_p=100; //psi
// orifice diameter:
D=1; //in
// specific gravity of oil:
SG_oil=0.9;
// flow coefficient for sharp edge orifice:
C=0.80;
```

Scilab code Exa 8.4.b SOLUTION flow rate through the orifice

```
clc;
pathname=get_absolute_file_path('8_4_soln.sce')
filename=pathname+filesep()+'8_4_data.sci'
exec(filename)

// Solution:
// flow-rate through orifice,
Q=38.1*C*((%pi*(D^2))/4)*sqrt(del_p/SG_oil); //gpm

// Results:
printf("\n  Results:  ")
printf("\n The flow-rate through orifice is %.0f gpm
   .",Q)
```

Scilab code Exa 8.5.a determine capacity coefficient of flowcontrol valve

```
// Aim:To determine the capacity coefficient of flow
    control valve
// Given:
// pressure drop across flow control valve:
del_p=100; //psi
del_p1=687; //kPa
// flow-rate across valve:
Q=25; //gpm
Q1=94.8; //Lpm
// specific gravity of oil:
SG_oil=0.9;
```

Scilab code Exa 8.5.b SOLUTION capacity coefficient of flowcontrol valve

```
clc;
pathname=get_absolute_file_path('8_5_soln.sce')
filename=pathname+filesep()+'8_5_data.sci'
exec(filename)

// Solution:
// capacity coefficient in English Units,
Cv=Q/sqrt(del_p/SG_oil); //gpm/sqrt(psi)
// capacity coefficient in Metric Units,
Cv1=Q1/sqrt(del_p1/SG_oil); //Lpm/sqrt(kPA)

// Results:
printf("\n  Results:  ")
printf("\n The capacity coefficient in English unit
    is %.2f gpm/sqrt(psi).",Cv)
```

```
printf("\n The capacity coefficient in Metric unit
    is %.2f Lpm/sqrt(kPa).",Cv1)
```

Scilab code Exa 8.6.a determine capacity coefficient of needle valve

```
// Aim:To determine the capacity coefficient of
    needle valve
// Given:
// Desired cylinder speed:
v2=10; //in/s
// Cylinder piston area:
A1=3.14; //in^2
// Cylinder rod area:
Ar=0.79; //in^2
// Cylinder load:
F_load=1000; //lb
// Specific gravity of oil:
SG_oil=0.9;
// Pressure relief valve setting:
p1=500; //psi
```

Scilab code Exa 8.6.b SOLUTION capacity coefficient of needle valve

```
clc;
pathname=get_absolute_file_path('8_6_soln.sce')
filename=pathname+filesep()+'8_6_data.sci'
exec(filename)

// Solution:
// annular area of cylinder,
A2=A1-Ar; //in^2
// back pressure in the rod end,
p2=((p1*A1)-F_load)/A2; //psi
```

```
// flow rate through needle valve based on desired
   cylinder speed,
Q=(A2*v2*60)/231; //gpm
// capacity coefficient of needle valve,
Cv=Q/sqrt(p2/SG_oil); //gpm/sqrt(psi)

// Results:
printf("\n  Results:  ")
printf("\n The capacity coefficient of needle valve
   is %.2f gpm/sqrt(psi).",Cv)
```

Chapter 9

HYDRAULIC CIRCUIT DESIGN AND ANALYSIS

Scilab code Exa 9.1.a determine speed power for regenerative circuit

```
// Aim:Refer Example 9-1 for Problem Description
// Given:
// cracking pressure of relief valve:
p=1000; //psi
// piston area:
Ap=25; //in^2
// rod area:
Ar=7; //in^2
// pump flow:
Qp=20; //gpm
```

Scilab code Exa 9.1.b SOLUTION speed power for regenerative circuit

```
clc;
pathname=get_absolute_file_path('9_1_soln.sce')
filename=pathname+filesep()+'9_1_data.sci'
```

```
exec(filename)

// Solution:
// cylinder speed during extending stroke,
vp_ext=(Qp*231)/(Ar*60); //in/s
// load carrying capacity during extending stroke,
Fload_ext=p*Ar; //lb
// power delivered to load during extending stroke,
Power_ext=(Fload_ext*vp_ext)/(550*12); //HP
// cylinder speed during retracting stroke,
vp_ret=(Qp*231)/((Ap-Ar)*60); //in/s
// load carrying capacity during retracting stroke,
Fload_ret=p*(Ap-Ar); //lb
// power delivered to load during retracting stroke,
Power_ret=(Fload_ext*vp_ext)/(550*12); //HP

// Results:
printf("\n  Results:  ")
printf("\n The cylinder speed during extending stroke is %.1f in/s.",vp_ext)
printf("\n The load carrying capacity during extending stroke is %.0f lb.",Fload_ext)
printf("\n The power delivered to load during extending stroke is %.1f HP.",Power_ext)
printf("\n The cylinder speed during retracting stroke is %.2f in/s.",vp_ret)
printf("\n The load carrying capacity during retracting stroke is %.0f lb.",Fload_ret)
printf("\n The power delivered to load during retracting stroke is %.1f HP.",Power_ret)
```

Scilab code Exa 9.2.a find unloading relief valve pressure settings

```
// Aim:Refer Example 9-2 for Problem Description
// Given:
```

```
// force required for sheet metal punching
   operations:
F_load=2000; //lb
// piston diameter:
Dp=1.5; //in
// rod diameter:
Dr=0.5; //in
// frictional pressure loss in line from high-flow
   pump to blank end during rapid extension:
p_loss1=100; //psi
// frictional pressure loss in return line from rod
   end to oil tank during rapid extension:
p_loss2=50; //psi
```

Scilab code Exa 9.2.b SOLUTION unloading relief valve pressure settings

```
clc;
pathname=get_absolute_file_path('9_2_soln.sce')
filename=pathname+filesep()+'9_2_data.sci'
exec(filename)

// Solution:
// Unloading Valve:
// load due to back pressure force on cylinder,
F_back_pressure=(p_loss2*%pi*((Dp^2)-(Dr^2)))/4; //
   psi
// back pressure force on cylinder,
P_cyl_blank_end=F_back_pressure/((%pi*(Dp^2))/4); //
   psi
// pressure setting of the unloading valve,
p_unload=1.5*(P_cyl_blank_end+p_loss1); //psi

// Pressure Relief Valve:
// pressure to overcome punching operations,
P_punching=F_load/((%pi*(Dp^2))/4); //psi
```

```
// pressure setting of the pressure relief valve,
p_prv=1.5*P_punching; //psi

// Results:
printf("\n  Results:  ")
printf("\n The pressure setting of unloading valve is %.0f psi.",p_unload)
printf("\n The pressure setting of pressure relief valve is %.0f psi.",p_prv)
```

Scilab code Exa 9.3.a find spring constant of PRV valve

```
// Aim:Refer Example 9-3 for Problem Description
// Given:
// poppet area:
A_poppet=0.75; //in^2
// hydraulic pressure:
p_hydraulic=1698; //psi
// full poppet stroke:
l_stroke=0.10; //in
// cracking pressure:
p_cracking=1.1*1132; //psi
```

Scilab code Exa 9.3.b SOLUTION spring constant of PRV valve

```
clc;
pathname=get_absolute_file_path('9_3_soln.sce')
filename=pathname+filesep()+'9_3_data.sci'
exec(filename)

// Solution:
// spring force at full pump flow pressure,
F_spr_full=round(p_hydraulic*A_poppet); //lb
```

```
// spring force at cracking pressure,
F_spr_crack=round(p_cracking*A_poppet); //lb
// spring constant of compression spring,
k=(F_spr_full-F_spr_crack)/l_stroke; //lb/in
// initial compression of spring,
l=F_spr_crack/k; //in

// Results:
printf("\n  Results:  ")
printf("\n The spring constant of compression spring
    is %.0f lb/in.",k)
printf("\n The initial compression of spring is %.3f
    in.",l)
```

Scilab code Exa 9.4.a determine cylinder speed of meterin circuit

```
// Aim:To determine cylinder speed for given meter-
    in circuit
// Given:
// valve capacity coefficient:
Cv=1.0; //gpm/sqrt(psi)
// cylinder piston diameter and area:
D=2; //in
A_piston=3.14; //in^2
// cylinder load:
F_load=4000; //lb
// specific gravity of oil:
SG=0.9;
// pressure relief valve setting:
p_PRV=1400; //psi
```

Scilab code Exa 9.4.b SOLUTION cylinder speed of meterin circuit

```
clc;
pathname=get_absolute_file_path('9_4_soln.sce')
filename=pathname+filesep()+'9_4_data.sci'
exec(filename)

// Solution:
// flow-rate through valve,
Q=Cv*sqrt((p_PRV-(F_load/A_piston))/SG); //gpm
// flow-rate through valve in in^3/s,
Q=(Q*231)/60; //in^3/s
// cylinder speed,
v_cyl=Q/A_piston; //in/s

// Results:
printf("\n  Results:  ")
printf("\n The cylinder speed is %.1f in/s.",v_cyl)
```

Scilab code Exa 9.5.a find overall efficiency of given system

```
// Aim:Refer Example 9-5 for Problem Description
// Given:
// Pump:
// mechanical efficiency:
eff_m_pump=92; //%
// volumetric efficiency:
eff_v_pump=94; //%
// volumetric displacement:
V_D_pump=10; //in^3
// speed of pump:
Np=1000; //rpm
// inlet pressure:
pi=-4; //psi

// Hydraulic Motor:
// mechanical efficiency:
```

```
eff_m_motor=92; //%
// volumetric efficiency:
eff_v_motor=90; //%
// volumetric displacement:
V_D_motor=8; //in^3
// inlet pressure required to drive load:
p2=500; //psi
// motor discharge pressure:
po=5; //psi

// Pipe and Fittings:
// inside diameter of pipe:
D=1.040; //in
// Length of pipe between station 1 and 2:
L_pipe=50; //ft
// K factor of standard 90 deg elbow:
K_elbow=0.75;
// K factor of check valve:
K_check=4.0;

// Oil:
// kinematic viscosity of oil:
nu=125; //cS
// specific gravity of oil:
SG=0.9;
```

Scilab code Exa 9.5.b SOLUTION overall efficiency of given system

```
clc;
pathname=get_absolute_file_path('9_5_soln.sce')
filename=pathname+filesep()+'9_5_data.sci'
exec(filename)

// Solution:
// acceleration due to gravity,
```

```
g=32.2; //ft/s^2
// pump's theoretical flow-rate,
Q_T_pump=(V_D_pump*Np)/231; //gpm
// pump's actual flow-rate,
Q_A_pump=(Q_T_pump*eff_v_pump)/100; //gpm
// velocity of oil,
v=((Q_A_pump)/449)/((%pi*((D/12)^2))/4); //ft/s
// Reynolds number,
N_R=(7740*v*D)/nu;
// friction factor,
f=64/N_R;
// equivalent length of 90 deg standard elbow,
Le_elbow=(K_elbow*(D/12))/f; //ft
// equivalent length of check valve,
Le_check_valve=(K_check*(D/12))/f; //ft
// total length of pipe,
LeTOT=L_pipe+(2*Le_elbow)+Le_check_valve; //ft
// head loss due to friction,
H_L=(f*LeTOT*(v^2))/(2*g*(D/12)); //ft
// head developed due to hydraulic motor and pump,
Hp=0; //ft
Hm=0; //ft
// height difference between station 1 and station 2,
Z=20; //ft
// pump discharge pressure,
p1=(((Z+H_L+Hm+Hp)*SG*62.4)/144)+p2; //psi
// input HP required to drive pump,
HP_pump=((p1-pi)*Q_A_pump)/(1714*(eff_m_pump/100)*(eff_v_pump/100)); //Hp
// motor theoretical power,
Q_T_motor=Q_A_pump*(eff_v_motor/100); //gpm
// speed of motor,
N_motor=floor((Q_T_motor*231)/V_D_motor); //rpm
// motor input horsepower,
HP_input_motor=((p2-po)*Q_A_pump)/1714; //HP
// rounding off the above answer
HP_input_motor=fix(HP_input_motor)+(fix(ceil((
```

```
HP_input_motor-fix(HP_input_motor))*10))/10); //HP
// motor output horsepower,
HP_output_motor=(HP_input_motor*(eff_m_motor/100)*(eff_v_motor/100)); //HP
// motor output torque,
T_output_motor=(HP_output_motor*63000)/N_motor; //in.lb
// overall efficiency of system,
eff_overall=(HP_output_motor/HP_pump)*100; //%
// rounding off the above answer
eff_overall=fix(eff_overall)+(fix(ceil((eff_overall-fix(eff_overall))*10))/10); //%

// Results:
printf("\n  Results:  ")
printf("\n The Pump flow-rate is %.1f gpm.",Q_A_pump)
printf("\n The Pump discharge pressure is %.0f psi.",p1)
printf("\n The Input HP required to drive the pump is %.1f HP.",HP_pump)
printf("\n The Motor Speed is %.0f rpm.",N_motor)
printf("\n The Motor output torque is %.0f in.lb.",T_output_motor)
printf("\n The Overall efficiency of system is %.1f percent.",eff_overall)
```

Chapter 10

HYDRAULIC CONDUCTORS AND FITTINGS

Scilab code Exa 10.1.a find minimum inside diameter of pipe

```
// Aim:To find minimum inside diameter of pipe
// Given:
// flow-rate through pipe:
Q=30; //gpm
// average fluid velocity:
v=20; //ft/s
```

Scilab code Exa 10.1.b SOLUTION minimum inside diameter of pipe

```
clc;
pathname=get_absolute_file_path('10_1_soln.sce')
filename=pathname+filesep()+'10_1_data.sci'
exec(filename)

// Solution:
// flow-rate in ft^3/s,
```

```
Q_fps=Q/449; //ft^3/s
// minimum required pipe flow area,
A=(Q_fps/v)*144; //in^2
// minimum inside diameter,
D=sqrt((4*A)/(%pi)); //in

// Results:
printf("\n  Results:  ")
printf("\n The minimum inside diameter of pipe is %
   .3f in.",D)
```

Scilab code Exa 10.2.a find minimum inside diameter in SI

```
// Aim:To find minimum inside diameter of pipe in
   Metric units
// Given:
// flow-rate through pipe:
Q=0.002; //m^3/s
// average fluid velocity:
v=6.1; //m/s
```

Scilab code Exa 10.2.b SOLUTION minimum inside diameter in SI

```
clc;
pathname=get_absolute_file_path('10_2_soln.sce')
filename=pathname+filesep()+'10_2_data.sci'
exec(filename)

// Solution:
// minimum required pipe flow area,
A=(Q/v); //m^2
// minimum inside diameter,
D=sqrt((4*A)/(%pi))*1000; //mm
```

```

// Results:
printf("\n Results: ")
printf("\n The minimum inside diameter of pipe is %.1f mm.",D)
```

Scilab code Exa 10.3.a find safe working pressure of tube

```
// Aim:To find safe working pressure for the tube
// Given:
// outside diameter of steel tube:
Do=1.250; //in
// inside diameter of steel tube:
Di=1.060; //in
// tensile strength of steel tube:
S=55000; //psi
// factor of safety:
FS=8;
```

Scilab code Exa 10.3.b SOLUTION safe working pressure of tube

```
clc;
pathname=get_absolute_file_path('10_3_soln.sce')
filename=pathname+filesep()+'10_3_data.sci'
exec(filename)

// Solution:
// wall thickness,
t=(Do-Di)/2; //in
// burst pressure,
BP=(2*t*S)/Di; //psi
// working pressure,
WP=BP/FS; //psi
```

```

// Results:
printf("\n  Results:  ")
printf("\n The working pressure of steel tube is %.0
   f psi.",WP)
printf("\n The answer in the program is different
   than that in textbook. It may be due to no.s of
   significant digit in data and calculation")
```

Scilab code Exa 10.4.a select proper size steel tube

```
// Aim:Refer Example 10-4 for Problem Description
// Given:
// flow-rate:
Q=30; //gpm
// operating pressure:
p=1000; //psi
// maximum velocity:
v=20; //ft/s
// tensile strength of material:
S=55000; //psi
// factor of safety:
FS=8;
```

Scilab code Exa 10.4.b SOLUTION proper size steel tube

```
clc;
pathname=get_absolute_file_path('10_4_soln.sce')
filename=pathname+filesep()+'10_4_data.sci'
exec(filename)

// Solutions:
// flow-rate,
```

```
Q=Q/449; //ft^3/s
// minimum required pipe flow area,
Ai=(Q/v)*144; //in^2
// minimum inside diameter,
Di=sqrt((4*Ai)/(%pi)); //in
// wall thickness,
t1=0.049; t2=0.065; //in
// tube inside diameter,
D1=0.902; D2=0.870; //in
// burst pressure,
BP1=(2*t1*S)/D1; //psi
// working pressure,
WP1=BP1/FS; //psi
printf(" \n The working pressure %.0f psi is not
   adequate (less than %.0f psi) so next case is
   considered,",WP1,p)
// burst pressure,
BP2=(2*t2*S)/D2; //psi
// working pressure,
WP2=BP2/FS; //psi
// ratio of inner diameter to thickness,
r2=D2/t2;
printf(" \n The working pressure %.0f psi is greater
    than %.0f psi) ,",WP2,p)

// Results:
printf("\n  Results:  ")
printf("\n The ratio of inner diameter to length is
   %.1f.",r2)
printf("\n The answer in the program is different
   than that in textbook. It may be due to no.s of
   significant digit in data and calculation")
```

Scilab code Exa 10.5.a select proper size steel tube SI

```
// Aim:Refer Example 10-5 for Problem Description
// Given:
// flow-rate:
Q=0.00190; //m^3/s
// operating pressure:
p=70; //bars
// maximum velocity:
v=6.1; //m/s
// tensile strength of material:
S=379; //MPa
// factor of safety:
FS=8;
```

Scilab code Exa 10.5.b SOLUTION proper size steel tube SI

```
clc;
pathname=get_absolute_file_path('10_5_soln.sce')
filename=pathname+filesep()+'10_5_data.sci'
exec(filename)

// Solutions:
// minimum required pipe flow area,
A=(Q/v); //m^2
// minimum inside diameter,
ID=sqrt((4*A)/(%pi))*1000; //mm
// wall thickness,
t1=1; t2=2; //mm
// tube inside diameter,
D1=20; D2=24; //mm
// burst pressure,
BP1=(2*(t1/1000)*S)/(D1/1000); //MPa
// working pressure,
WP1=(BP1/FS)*10; //bars
printf("\n The working pressure %.0f bars is not
    adequate (less than %.0f bars) so next case is
```

```
    considered ,",WP1,p)
// burst pressure,
BP2=(2*(t2/1000)*S)/(D2/1000); //MPa
// working pressure,
WP2=(BP2/FS)*10;; //MPa
// ratio of inner diameter to thickness,
r2=D2/t2;
printf(" \n The working pressure %.0f bars is
    greater than %.0f bars) ,",WP2,p)



// Results:
printf("\n  Results:  ")
printf("\n The ratio of inner diameter to length is
    %.1f.",r2)
```

Chapter 11

ANCILLARY HYDRAULIC DEVICES

Scilab code Exa 11.1.a find the discharge flow and pressure

```
// Aim:To find the discharge flow and pressure
// Given:
// high inlet flow-rate:
Q_high_inlet=20; //gpm
// low inlet pressure:
p_low_inlet=500; //psi
// Ratio of piston area to rod area:
Ratio=5/1;
```

Scilab code Exa 11.1.b SOLUTION the discharge flow and pressure

```
clc;
pathname=get_absolute_file_path('11_1_soln.sce')
filename=pathname+filesep()+'11_1_data.sci'
exec(filename)

```

```
// Solution:
// high discharge pressure,
p_high_discharge=Ratio*p_low_inlet; //psi
// low discharge flow-rate,
Q_low_discharge=Q_high_inlet/Ratio; //gpm

// Results:
printf("\n  Results:  ")
printf("\n The high discharge pressure is %.0f psi.",p_high_discharge)
printf("\n The low discharge flow-rate is %.0f gpm.",Q_low_discharge)
```

Scilab code Exa 11.2.a determine the downstream oil temperature

```
// Aim:To find the downstream oil temperature
// Given:
// temperature of oil flowing through pressure relief valve:
T_oil=120; //deg F
// pressure of oil flowing through pressure relief valve:
p=1000; //psi
// oil flow through pressure relief valve:
Q_gpm=10; //gpm
```

Scilab code Exa 11.2.b SOLUTION the downstream oil temperature

```
clc;
pathname=get_absolute_file_path('11_2_soln.sce')
filename=pathname+filesep()+'11_2_data.sci'
exec(filename)

```

```
// Solution:
// heat generation rate,
HP=(p*Q_gpm)/1714; //HP
// heat generation rate in Btu/min,
HP_btu=HP*42.4; //Btu/min
// oil flow-rate in lb/min,
Q_lb=7.42*Q_gpm; //lb/min
// temperature increase,
T_increase=HP_btu/(0.42*Q_lb); //deg F
// downward oil temperature,
T_downward=T_oil+T_increase; //deg F

// Results:
printf("\n  Results:  ")
printf("\n The downstream oil temperature is %.1f
   deg F.",T_downward)
```

Scilab code Exa 11.3.a determine downstream oil temperature in SI

```
// Aim:To find the downstream oil temperature in SI
   Unit
// Given:
// temperature of oil flowing through pressure
   relief valve:
T_oil=50; //deg C
// pressure of oil flowing through pressure relief
   valve:
p=70; //bar
// oil flow through pressure relief valve:
Q=0.000632; //m^3/s
```

Scilab code Exa 11.3.b SOLUTION downstream oil temperature in SI

```
clc;
pathname=get_absolute_file_path('11_3_soln.sce')
filename=pathname+filesep()+'11_3_data.sci'
exec(filename)

// Solution:
// heat generation rate,
kW=((p*10^5)*Q)/1000; //kW
// oil flow-rate,
Q_kg_s=895*Q; //kg/s
// temperature increase,
T_increase=kW/(1.8*Q_kg_s); //deg C
// downward oil temperature,
T_downward=T_oil+T_increase; //deg C

// Results:
printf("\n  Results:  ")
printf("\n The downstream oil temperature is %.1f deg C.",T_downward)
```

Scilab code Exa 11.4.a find heat exchanger rating of system

```
// Aim:To find the rating of heat exchanger required to dissipate generated heat
// Given:
// oil flow-rate:
Q=20; //gpm
// operating pressure:
p=1000; //psi
// overall efficiency of pump:
eff_overall=85; //%
// power lost due to friction:
HP_frict=10; //%
```

Scilab code Exa 11.4.b SOLUTION heat exchanger rating of system

```
clc;
pathname=get_absolute_file_path('11_4_soln.sce')
filename=pathname+filesep()+'11_4_data.sci'
exec(filename)

// Solution:
// pump power loss,
pump_HP_loss=((1/(eff_overall/100))-1)*((p*Q)/1714);
    //HP
// PRV average HP loss,
PRV_loss=0.5*((p*Q)/1714); //HP
// line average HP loss,
line_loss=(HP_frict/100)*PRV_loss; //HP
// total average loss,
total_loss=pump_HP_loss+PRV_loss+line_loss; //HP
// heat exchanger rating,
HEx_rating=total_loss*2544; //Btu/hr

// Results:
printf("\n  Results:  ")
printf("\n The heat exchanger rating is %.0f Btu/hr.
   ",HEx_rating)
printf("\n The answer in the program does not match
   with that in the textbook due to roundoff error (
   standard ratings) in textbook")
```

Scilab code Exa 11.5.a find heat exchanger rating in SI

```
// Aim:To find the rating of heat exchanger required
    to dissipate generated heat in SI unit
```

```
// Given:
// oil flow-rate:
Q=0.00126; //m^3/s
// operating pressure:
p=70; //bar
// overall efficiency of pump:
eff_overall=85; //%
// power lost due to friction:
HP_frict=10; //%
```

Scilab code Exa 11.5.b SOLUTION heat exchanger rating in SI

```
clc;
pathname=get_absolute_file_path('11_5_soln.sce')
filename=pathname+filesep()+'11_5_data.sci'
exec(filename)

// Solution:
// pump power loss,
pump_loss=((1/(eff_overall/100))-1)*((p*10^5*Q)
    /1000); //kW
// PRV average HP loss,
PRV_loss=0.5*((p*10^5*Q)/1000); //kW
// line average HP loss,
line_loss=(HP_frict/100)*PRV_loss; //kW
// total average loss,
HEx_rating=pump_loss+PRV_loss+line_loss; //kW

// Results:
printf("\n  Results:  ")
printf("\n The heat exchanger rating is %.2f kW.",
    HEx_rating)
```

Chapter 13

PNEUMATICS AIR PREPARATION AND COMPONENTS

Scilab code Exa 13.1.a find final pressure at constant temperature

```
// Aim:To find new pressure in cylinder when its
   blank end is blocked
// Given:
// diameter of pneumatic piston:
D=2; //in
// length of retraction of piston:
l_ret=4; //in
// blank side pressure:
p1=20; //psig
// volume of cylinder for extension stroke:
V1=20; //in^3
```

Scilab code Exa 13.1.b SOLUTION final pressure at constant temperature

```
clc;
pathname=get_absolute_file_path('13_1_soln.sce')
filename=pathname+filesep()+'13_1_data.sci'
exec(filename)

// Solution:
// volume of cylinder during retraction stroke,
V2=(V1-((%pi * D^2 * l_ret)/4)); //in^3
// absolute pressure on blank side,
p1=p1+14.7; //psia
// new pressure when blank side port is blocked,
// Boyle's Law,
p2=(p1*V1)/V2; //psia
p2=p2-14.7; //psig

// Results:
printf("\n  Results:  ")
printf("\n The new pressure when blank side port is
    blocked is %.1f psig.",p2)
```

Scilab code Exa 13.2.a find final volume at constant pressure

```
// Aim:To find new volume of air at the blank end of
    cylinder
// Given:
// initial volume:
V1=20; //in^3
// constant load:
p=20; //psi
// initial temperature of air:
T1=60; //deg F
// final temperature of air:
T2=120; //degF
```

Scilab code Exa 13.2.b SOLUTION final volume at constant pressure

```
clc;
pathname=get_absolute_file_path('13_2_soln.sce')
filename=pathname+filesep()+'13_2_data.sci'
exec(filename)

// Solution:
// initial temperature of air in Rankine,
T1=T1+460; //deg R
// final temperature of air in Rankine,
T2=T2+460; //deg R
// final volume of air,
// Charle's Law,
V2=(T2/T1)*V1; //in^3

// Results:
printf("\n  Results:  ")
printf("\n The final volume of air is %.1f in^3.",V2)
```

Scilab code Exa 13.3.a find final pressure at constant volume

```
// Aim:To find new pressure in cylinder when it is at locked position
// Given:
// initial pressure:
p1=20; //psig
// initial temperature of air:
T1=60; //deg F
// final temperature of air:
T2=160; //degF
```

Scilab code Exa 13.3.b SOLUTION final pressure at constant volume

```
clc;
pathname=get_absolute_file_path('13_3_soln.sce')
filename=pathname+filesep()+'13_3_data.sci'
exec(filename)

// Solution:
// initial temperature of air in Rankine,
T1=T1+460; //deg R
// final temperature of air in Rankine,
T2=T2+460; //deg R
// absolute initial pressure,
p1=p1+14.7; //psia
// final pressure of air,
// Gay-Lussac's Law,
p2=(T2/T1)*p1; //psia
p2=p2-14.7; //psig

// Results:
printf("\n  Results:  ")
printf("\n The final pressure of air at constant
    volume is %.1f psig.",p2)
```

Scilab code Exa 13.4.a find final pressure general gas law

```
// Aim:To find final pressure in the cylinder
// Given:
// initial gas pressure:
p1=1000; //psig
// initial volume of cylinder:
```

```
V1=2000; //in^3
// initial temperature of cylinder:
T1=100; //deg F
// final volume of cylinder:
V2=1500; //in^3
// final temperature of cylinder:
T2=200; //deg F
```

Scilab code Exa 13.4.b SOLUTION final pressure general gas law

```
clc;
pathname=get_absolute_file_path('13_4_soln.sce')
filename=pathname+filesep()+'13_4_data.sci'
exec(filename)

// Solution:
// final pressure in the cylinder,
// General Gas Law,
p2=((p1+14.7)*V1*(T2+460))/(V2*(T1+460))-14.7; //
    psig

// Results:
printf("\n  Results:  ")
printf("\n The final pressure in the cylinder is %.1
    f psig.",p2)
```

Scilab code Exa 13.5.a find final pressure general law SI

```
// Aim:To find final pressure in the cylinder in SI
    units
// Given:
// initial gas pressure:
p1=70; //bar
```

```
// initial volume of cylinder:
V1=12900; //cm^3
// initial temperature of cylinder:
T1=37.8; //deg C
// final volume of cylinder:
V2=9680; //cm^3
// final temperature of cylinder:
T2=93.3; //deg C
```

Scilab code Exa 13.5.b SOLUTION final pressure general law SI

```
clc;
pathname=get_absolute_file_path('13_5_soln.sce')
filename=pathname+filesep()+'13_5_data.sci'
exec(filename)

// Solution:
// final pressure in the cylinder in absolute units,
// General Gas Law,
p2=(((p1+1)*10^5*V1*(T2+273))/(V2*(T1+273)))/10^5;
   //bars

// Results:
printf("\n  Results:  ")
printf("\n The final pressure in the cylinder is %.1
   f bars absolute.",p2)
```

Scilab code Exa 13.6.a how much air compressor must provide

```
// Aim:To find how many cfm of free air compressor
   must be provided
// Given:
// flow-rate of air from receiver:
```

```
Q2=30; //cfm
// temperature of air from receiver:
T2=90; //deg F
// pressure of air coming from receiver:
p2=125; //psig
// atmospheric temperature:
T1=70; //deg F
// atmospheric pressure:
p1=14.7; //psig
```

Scilab code Exa 13.6.b SOLUTION air compressor must provide

```
clc;
pathname=get_absolute_file_path('13_6_soln.sce')
filename=pathname+filesep()+'13_6_data.sci'
exec(filename)

// Solution:
// cfm of free air compressor must be provided,
Q1=Q2*((p2+14.7)/14.7)*((T1+460)/(T2+460)); //cfm

// Results:
printf("\n  Results:  ")
printf("\n The cfm of free air compressor must be
    provided is %.0f cfm of free air.",Q1)
```

Scilab code Exa 13.7.a find receiver size for pneumatic system

```
// Aim:Refer Example 13-7 for Problem Description
// Given:
// maximum pressure level in receiver:
p_max=100; //psi
// minimum pressure level in receiver:
```

```
p_min=80; //psi
// time that receiver can supply required amount of
   air:
t=6; //min
// consumption rate of pneumatic system:
Qr=20; //scfm
// output flow-rate of compressor:
Qc=5; //scfm
```

Scilab code Exa 13.7.b SOLUTION receiver size for pneumatic system

```
clc;
pathname=get_absolute_file_path('13_7_soln.sce')
filename=pathname+filesep()+'13_7_data.sci'
exec(filename)

// Solution:
// required size of a receiver before compressor
   resumes operation,
Vr=((14.7*t*(Qr-0))/(p_max-p_min))*7.48; //gal
// required size of a receiver when compressor is
   running,
Vr_run=((14.7*t*(Qr-Qc))/(p_max-p_min))*7.48; //gal

// Results:
printf("\n  Results:  ")
printf("\n The required size of a receiver before
   compressor resumes operation is %.0f gal.",Vr)
printf("\n The required size of a receiver when
   compressor is running %.0f gal.",Vr_run)
```

Scilab code Exa 13.8.a determine actual power required for compressor

```
// Aim:To determine actual power required to drive a
    compressor
// Given:
// input flow-rate of air through compressor:
Q=100; //scfm
// inlet atmospheric pressure:
p_in=14.7; //psig
// outlet pressure:
p_out=114.7; //psig
// overall efficiency of compressor:
eff=75; //%
```

Scilab code Exa 13.8.b SOLUTION actual power required for compressor

```
clc;
pathname=get_absolute_file_path('13_8_soln.sce')
filename=pathname+filesep()+'13_8_data.sci'
exec(filename)

// Solution:
// theoretical horsepower,
HP_theo=((p_in*Q)/65.4)*((p_out/p_in)^0.286-1); //HP
// actual horsepower,
HP_act=HP_theo/(eff/100); //HP


// Results:
printf("\n  Results:  ")
printf("\n The actual power required to drive a
   compressor is %.0f HP.",HP_act)
```

Scilab code Exa 13.9.a find moisture received by pneumatic system

```
// Aim:Refer Example 13-9 for Problem Description
// Given:
// output flow-rate of compressor:
Qc=100; //scfm
// pressure at compressor outlet:
p_out=100; //psig
// temperature of saturated air at compressor inlet:
T_in=80; //deg F
// operation time of compressor per day:
t=8; //hr/day
```

Scilab code Exa 13.9.b SOLUTION moisture received by pneumatic system

```
clc;
pathname=get_absolute_file_path('13_9_soln.sce')
filename=pathname+filesep()+'13_9_data.sci'
exec(filename)

// Solution:
// from fig 13-29,
// entering moistue content at 80 deg F,
moist_in=1.58/1000; //lb/ft^3
// moisture rate which enters the compressor,
moist_rate=moist_in*Qc; //lb/min
// number of gallons/day received by pneumatic system,
gal_per_day=(moist_rate*60*t)/8.34; //gal/day
// moisture received by pneumatic system if aftercooler is installed,
// from fig 13-29,
moist_after=(1-((1.58-0.2)/1.58))*gal_per_day; //gal/day
// moisture received by pneumatic system if air dryer is installed,
```

```
// from fig 13-29,
moist_air_dryer=(1-((1.58-0.05)/1.58))*gal_per_day;
    //gal/day

// Results:
printf("\n  Results:  ")
printf("\n The number of gallons/day received by
    pneumatic system is %.2f gal/day.",gal_per_day)
printf("\n The moisture received by pneumatic system
     if aftercooler is installed is %.2f gal/day.",
    moist_after)
printf("\n The moisture received by pneumatic system
     if air dryer is installed is %.2f gal/day.",
    moist_air_dryer)
```

Scilab code Exa 13.10.a determine air maximum flowrate in scfm

```
// Aim:To determine maximum flow-rate in units of
    scfm of air
// Given:
// upstream temperature:
T1=80; //deg F
// upstream pressure:
p1=80; //psi
// flow capacity constant:
Cv=7.4;
// diameter of orifice:
d=0.5; //in
```

Scilab code Exa 13.10.b SOLUTION air maximum flowrate in scfm

```
clc;
pathname=get_absolute_file_path('13_10_soln.sce')
```

```
filename=pathname+filesep()+'13_10_data.sci'
exec(filename)

// Solution:
// upstream temperature in Rankine,
T1=T1+460; //deg R
// absolute upstream pressure,
p1=p1+14.7; //psia
// for maximum flow-rate,
// absolute downstream pressure,
p2=0.53*p1; //psia
// volume flow-rate,
Q=floor(22.7*Cv*sqrt(((p1-p2)*p2)/T1)); //scfm

// Results:
printf("\n  Results:  ")
printf("\n The maximum flow-rate is %.0f scfm of air
    .",Q)
```

Scilab code Exa 13.11.a determine flow capacity constant of system

```
// Aim:To determine size valve (Cv) for
    pneumatically powered impact tool
// Given:
// volume flow-rate of air:
Q=50; //scfm
// downstream pressure:
p2=100; //psi
// pressure drop across valve:
del_p=12; //psi
// upstream air temperature:
T1=80; //deg F
```

Scilab code Exa 13.11.b SOLUTION flow capacity constant of system

```
clc;
pathname=get_absolute_file_path('13_11_soln.sce')
filename=pathname+filesep()+'13_11_data.sci'
exec(filename)

// Solution:
// upstream temperature in Rankine,
T1=T1+460; //deg R
// absolute downstream pressure,
p2=p2+14.7; //psia
// flow capacity constant,
Cv=(Q/22.7)*sqrt(T1/(p2*del_p));

// Results:
printf("\n  Results:  ")
printf("\n The flow capacity constant is %.2f.",Cv)
```

Scilab code Exa 13.12.a determine air consumption rate in scfm

```
// Aim:To determine the air-consumption rate in scfm
// Given:
// piston diameter of pneumatic cylinder:
d=1.75; //in
// stroke length of cylinder:
L=6; //in
// number of cycles per minute:
N=30; //cycles/min
// atmospheric temperature:
T1=68; //deg F
// atmospheric pressure:
p1=14.7; //psia
// temperature of air in pneumatic cylinder:
T2=80; //deg F
```

```
// pneumatic cylinder pressure:
p2=100; //psig
```

Scilab code Exa 13.12.b SOLUTION air consumption rate in scfm

```
clc;
pathname=get_absolute_file_path('13_12_soln.sce')
filename=pathname+filesep()+'13_12_data.sci'
exec(filename)

// Solution:
// atmospheric temperature in deg Rankine,
T1=T1+460; //deg R
// temperature of air in deg Rankine in pneumatic cylinder,
T2=T2+460; //deg R
// absolute pneumatic cylinder pressure,
p2=p2+14.7; //psia
// the volume per minute of air consumed by cylinder,
Q2=(%pi/4)*(d/12)^2*(L/12)*N; //ft^3/min
// air consumption rate,
Q1=Q2*(p2/p1)*(T1/T2); //scfm

// Results:
printf("\n  Results:  ")
printf("\n The air consumption rate in scfm is %.2f.",Q1)
```

Scilab code Exa 13.13.a find reciprocation rate of pneumatic cylinder

```
// Aim:To determine the piston reciprocation rate
// Given:
```

```
// piston diameter of pneumatic cylinder:
d=44.5; //mm
// stroke length of cylinder:
L=152; //mm
// atmospheric temperature:
T1=20; //deg C
// atmospheric pressure:
p1=101; //kPa
// temperature of air in pneumatic cylinder:
T2=27; //deg C
// pneumatic cylinder pressure:
p2=687; //kPa
// air consumption rate:
Q1=0.0555; //m^3/min
```

Scilab code Exa 13.13.b SOLUTION reciprocation rate of pneumatic cylinder

```
clc;
pathname=get_absolute_file_path('13_13_soln.sce')
filename=pathname+filesep()+'13_13_data.sci'
exec(filename)

// Solution:
// atmospheric temperature in kelvin,
T1=T1+273; //K
// temperature of air in kelvin in pneumatic
   cylinder,
T2=T2+273; //K
// absolute pneumatic cylinder pressure,
p2=p2+101; //kPa abs
// flow-rate of air consumed by cylinder,
Q2=Q1*(p1/p2)*(T2/T1); //m^3/min
// reciprocation rate of piston,
N=floor(Q2/((%pi/4)*(d/1000)^2*(L/1000))); //cycles/
```

```
   min

// Results:
printf("\n  Results:  ")
printf("\n The reciprocation rate of piston is %.0f
   cycles/min.",N)
```

Chapter 14

PNEUMATICS CIRCUITS AND APPLICATIONS

Scilab code Exa 14.1.a find pressure loss for given pipe

```
// Aim:To find pressure loss for a 250 ft length of
   pipe
// Given:
// flow-rate:
Q=100; //scfm
// receiver pressure:
p2=150; //psi
// atmospheric pressure:
p1=14.7; //psi
// length of pipe:
L=250; //ft
```

Scilab code Exa 14.1.b SOLUTION pressure loss for given pipe

```
clc;
pathname=get_absolute_file_path('14_1_soln.sce')
```

```
filename=pathname+filesep()+'14_1_data.sci'
exec(filename)

// Solution:
// compression ratio,
CR=(p2+p1)/p1;
// from fig 14-3,
// inside diameter raised to 5.31,
k=1.2892; //in
// experimentally determined coefficient,
c=0.1025/(1)^0.31;
// pressure loss,
p_f=(c*L*Q^2)/(3600*CR*k); //psi

// Results:
printf("\n  Results:  ")
printf("\n The pressure loss for a 250 ft length of
   pipe is %.2f psi.",p_f)
```

Scilab code Exa 14.2.a find pressure loss with pipe valves

```
// Aim:To find pressure loss for a  pipe with valves
// Given:
// experimentally determined coefficient:
c=0.1025;
// compression ratio:
CR=11.2;
// receiver pressure:
p2=150; //psi
// atmospheric pressure:
p1=14.7; //psi
// length of pipe:
L=250; //ft
```

Scilab code Exa 14.2.b SOLUTION pressure loss with pipe valves

```
clc;
pathname=get_absolute_file_path('14_2_soln.sce')
filename=pathname+filesep()+'14_2_data.sci'
exec(filename)

// Solution:
// from fig 14-3,
// inside diameter raised to 5.31,
k=1.2892; //in
// length of pipe along with valves,
L=L+(2*0.56)+(3*29.4)+(5*1.5)+(4*2.6)+(6*1.23); //ft
// pressure loss,
p_f=(c*L*Q^2)/(3600*CR*k); //psi

// Results:
printf("\n  Results:  ")
printf("\n The pressure loss for a 250 ft length of
    pipe is %.2f psi.",p_f)
```

Scilab code Exa 14.3.a determine cost of electricity per year

```
// Aim:Refer Example 14-3 for Problem Description
// Given:
// air flow-rate:
Q=270; //scfm
// pressure at which compressor delivers air:
p_out=100; //psig
// overall efficiency of compressor:
eff_o=75; //%
```

```
// pressure at which compressor delivers air taking friction in account:
p_out1=115; //psig
// efficiency of electric motor driving compressor:
eff_mot=92; //%
// operating time of compressor:
t=3000; //hr/year
// cost of electricity per watt:
cost_per_wat=0.11; //$/kWh
```

Scilab code Exa 14.3.b SOLUTION cost of electricity per year

```
clc;
pathname=get_absolute_file_path('14_3_soln.sce')
filename=pathname+filesep()+'14_3_data.sci'
exec(filename)

// Solutions:
// inlet pressure,
p_in=14.7; //psi
// actual horsepower at 100 psig,
act_HP=((p_in*Q)/(65.4*(eff_o/100)))*(((p_out+14.7)/p_in)^0.286-1); //HP
// actual horsepower at 115 psig,
act_HP1=((p_in*Q)/(65.4*(eff_o/100)))*(((p_out1+14.7)/p_in)^0.286-1); //HP
// actual power at 100 psig in kW,
act_kW=act_HP*0.746; //kW
// electric power required to drive electric motor at 100 psig,
elect_kW=act_kW/(eff_mot/100); //kW
// cost of electricity per year at 100 psig,
yearly_cost=elect_kW*t*cost_per_wat; //$/yr
// actual power at 115 psig in kW,
act_kW1=act_HP1*0.746; //kW
```

```
// electric power required to drive electric motor at 115 psig,
elect_kW1=act_kW1/(eff_mot/100); //kW
// cost of electricity per year at 115 psig,
yearly_cost1=elect_kW1*t*cost_per_wat; //$/yr

// Results:
printf("\n  Results:  ")
printf("\n The actual HP required to drive the compressor at 100 psig is %.1f HP.",act_HP)
printf("\n The actual HP required to drive the compressor at 115 psig is %.1f HP.",act_HP1)
printf("\n The cost of electricity per year at 100 psig is %.0f $.",yearly_cost)
printf("\n The cost of electricity per year at 115 psig is %.0f $.",yearly_cost1)
printf("\n The answer in the program does not match with that in the textbook due to roundoff error (standard electric ratings)")
```

Scilab code Exa 14.4.a determine cost of leakage per year

```
// Aim:To determine the yearly cost of leakage of pneumatic system
// Given:
// air flow-rate:
Q=270; //scfm
// air flow-rate leakage:
Q_leak=70; //scfm
// // electric power required to drive electric motor at 100 psig:
elect_kW=52.3; //kW
// cost of electricity per watt:
cost_per_wat=0.11; //$/kWh
```

Scilab code Exa 14.4.b SOLUTION cost of leakage per year

```
clc;
pathname=get_absolute_file_path('14_4_soln.sce')
filename=pathname+filesep()+'14_4_data.sci'
exec(filename)

// Solutions:
// electric power required to compensate for leakage
   ,
power_rate=(Q_leak/Q)*elect_kW; //kW
// rounding off the above answer
power_rate=fix(power_rate)+(fix(round((power_rate-
   fix(power_rate))*10))/10); //kW
// cost of electricity per year at 100 psig,
yearly_leak=power_rate*24*365*cost_per_wat; //$/yr

// Results:
printf("\n  Results:  ")
printf("\n The cost of electricity for leakage per
   year at 100 psig is %.0f $.",yearly_leak)
printf("\n The answer in the program does not match
   with that in the textbook due to roundoff error(
   standard electric ratings)")
```

Scilab code Exa 14.5.a how heavy object can be lifted

```
// Aim:Refer Example 14-5 for Problem Description
// Given:
// diameter of suction cup lip outer circle:
Do=6; //in
// diameter of suction cup inner lip circle:
```

```
Di=5; //in
// atmospheric pressure:
p_atm=14.7; //psi
// suction pressure:
p_suc=-10; //psi
```

Scilab code Exa 14.5.b SOLUTION heavy object can be lifted

```
clc;
pathname=get_absolute_file_path('14_5_soln.sce')
filename=pathname+filesep()+'14_5_data.sci'
exec(filename)

// Solution:
// suction pressure in absolute,
p_suc_abs=p_suc+p_atm; //psia
// maximum weight that suction cup can lift,
F=ceil((p_atm*(%pi/4)*Do^2)-(p_suc_abs*(%pi/4)*Di^2)
    ); //lb
// maximum weight suction cup can lift with perfect
    vaccum,
W=p_atm*(%pi/4)*Do^2; //lb

// Results:
printf("\n  Results:  ")
printf("\n The maximum weight that suction cup can
    lift is %.0f lb.",F)
printf("\n The maximum weight that suction cup can
    lift with perfect vacuum is %.0f lb.",W)
```

Scilab code Exa 14.6.a determine time for achieving vacuum pressure

```
// Aim:To determine the time required to achieve the
    desired vacuum pressure
// Given:
// total volume of space in the suction cup:
V=6; //ft^3
// flow-rate produced by vacuum pump:
Q=4; //scfm
// desired suction pressure:
p_vacuum=6; //in Hg abs
// atmospheric pressure:
p_atm=30; //in Hg abs
```

Scilab code Exa 14.6.b SOLUTION time for achieving vacuum pressure

```
clc;
pathname=get_absolute_file_path('14_6_soln.sce')
filename=pathname+filesep()+'14_6_data.sci'
exec(filename)

// Solutions:
// time required to achieve the desired vacuum
   pressure,
t=(V/Q)*log(p_atm/p_vacuum); //min
// time required to achieve perfect vacuum pressure,
t1=(V/Q)*log(p_atm/0.5); //min

// Results:
printf("\n  Results:  ")
printf("\n The time required to achieve the desired
   vacuum pressure is %.2f min.",t)
printf("\n The time required to achieve perfect
   vacuum pressure is %.2f min.",t1)
```

Scilab code Exa 14.7.a calculate required size of the accumulator

```
// Aim:Refer Example 14-7 for Problem Description
// Given:
// diamter of hydraulic cylinder:
D=6; //in
// cylinder extension:
L=100; //in
// duration of cylinder extension:
t=10; //s
// time between crushing stroke:
t_crush=5; //min
// gas precharge pressure:
p1=1200; //psia
// gas charge pressure when pump is turned on:
p2=3000; //psia
// minimum pressure required to actuate load:
p3=1800; //psia
```

Scilab code Exa 14.7.b SOLUTION required size of the accumulator

```
clc;
pathname=get_absolute_file_path('14_7_soln.sce')
filename=pathname+filesep()+'14_7_data.sci'
exec(filename)

// Solutions:
// volume of hydraulic cylinder,
V=(%pi/4)*L*(D^2); //in^3
// volume of cylinder in charged position,
V2=V/((p2/p3)-1); //in^3
// volume of cylinder in final position,
V3=(p2/p3)*V2; //in^3
// required size of accumulator,
V1=((p2*V2)/p1)/231; //gal
```

```
// rounding off the above answer,
V1=fix(V1)+(fix(floor((V1-fix(V1))*10))/10); //gal
// pump flow-rate with accumulator,
Q_pump_acc=((2*V)/231)/t_crush; //gpm
// rounding off the above answer
Q_pump_acc=fix(Q_pump_acc)+(fix(ceil((Q_pump_acc-fix(Q_pump_acc))*100))/100); //gpm
// pump hydraulic power with accumulator,
HP_pump_acc=(Q_pump_acc*p2)/1714; //HP
// pump flow-rate without accumulator,
Q_pump_no_acc=(V/231)/(t/60); //gpm
// pump hydraulic power without accumulator,
HP_pump_no_acc=(Q_pump_no_acc*p3)/1714; //HP

// Results:
printf("\n  Results:  ")
printf("\n The required size of accumulator is %.1f gal.",V1)
printf("\n The pump hydraulic horsepower with accumulator is %.2f HP.",HP_pump_acc)
printf("\n The pump hydraulic horsepower without accumulator is %.1f HP.",HP_pump_no_acc)
printf("\n The answer in the program is different than that in textbook. It may be due to no.s of significant digit in data and calculation")
```

Scilab code Exa 14.8.a find electricity cost per year SI

```
// Aim:To calculate the cost of electricity per year in Metric Unit
// Given:
// air flow-rate:
Q=7.65; //m^3/min
// pressure at which compressor delivers air:
p_out=687; //kPa gage
```

```
// efficiency of compressor:
eff_o=75; //%
// efficiency of electric motor driving compressor:
eff_mot=92; //%
// operating time of compressor per year:
t=3000; //hr
// cost of electricity:
cost_per_wat=0.11; //$/kWh
```

Scilab code Exa 14.8.b SOLUTION electricity cost per year SI

```
clc;
pathname=get_absolute_file_path('14_8_soln.sce')
filename=pathname+filesep()+'14_8_data.sci'
exec(filename)

// Solutions:
// inlet pressure,
p_in=101; //kPa
// actual power,
act_kW=((p_in*Q)/(17.1*(eff_o/100)))*(((p_out+101)/
    p_in)^0.286-1); //kW
// electric power required to drive electric motor,
elect_kW=act_kW/(eff_mot/100); //kW
// rounding off the above answer
elect_kW=fix(elect_kW)+(fix(round((elect_kW-fix(
    elect_kW))*10))/10); //kW
// cost of electricity,
yearly_cost=elect_kW*t*cost_per_wat; //$/yr

// Results:
printf("\n  Results:  ")
printf("\n The cost of electricity per year is %.0f
    $.",yearly_cost)
printf("\n The answer in the program does not match
```

```
with that in the textbook due to roundoff error (
standard electric ratings)")
```

Scilab code Exa 14.9.a what flowrate vacuum pump must deliver

```
// Aim:To find the flow-rate to be delivered by vacuum pump
// Given:
// lip outside diameter of suction cup:
Do=100; //mm
// lip inside diameter of suction cup:
Di=80; //mm
// weight of steel sheets:
F=1000; //N
// numbers of suction cups:
N=4;
// total volume of space inside the suction cup:
V=0.15; //m^3
// factor of safety:
f=2;
// time required to produce desired vacuum pressure:
t=1; //min
```

Scilab code Exa 14.9.b SOLUTION flowrate vacuum pump must deliver

```
clc;
pathname=get_absolute_file_path('14_9_soln.sce')
filename=pathname+filesep()+'14_9_data.sci'
exec(filename)

// Solutions:
// atmospheric pressure,
p_atm=101000; //Pa
```

```
// lip outside area of suction cup,
Ao=(%pi/4)*(Do/1000)^2; //m^2
// lip inside area of suction cup,
Ai=(%pi/4)*(Di/1000)^2; //m^2
// required vacuum pressure,
p=((p_atm*Ao)-((F*f)/N))/Ai; //Pa abs
// flow-rate to be delivered by vacuum pump,
Q=(V/t)*log(p_atm/p); //m^3/min
// rounding off the above answer
Q=fix(Q)+(fix(ceil((Q-fix(Q))*10000))/10000); //m^3/
    min

// Results:
printf("\n  Results:  ")
printf("\n The flow-rate of air to be delivered by
    vacuum pump is %.4f m^3/min.",Q)
```

Scilab code Exa 14.10.a calculate required size of accumulator SI

```
// Aim:Refer Example 14-7 for Problem Description
// Given:
// diamter of hydraulic cylinder:
D=152; //mm
// cylinder extension:
L=2.54; //m
// duration of cylinder extension:
t=10; //s
// time between crushing stroke:
t_crush=5; //min
// gas precharge pressure:
p1=84; //bars abs
// gas charge pressure when pump is turned on:
p2=210; //bars abs
// minimum pressure required to actuate load:
p3=126; //bars abs
```

Scilab code Exa 14.10.b SOLUTION required size of accumulator SI

```
clc;
pathname=get_absolute_file_path('14_10_soln.sce')
filename=pathname+filesep()+'14_10_data.sci'
exec(filename)

// Solutions:
// volume of hydraulic cylinder,
V=(%pi/4)*L*((D/1000)^2); //m^3
// volume of cylinder in charged position,
V2=V/((p2/p3)-1); //m^3
// volume of cylinder in final position,
V3=(p2/p3)*V2; //m^3
// required size of accumulator,
V1=floor(((p2*V2)/p1)*1000); //L
// pump flow-rate with accumulator,
Q_pump_acc=(2*V*1000)/(t_crush*60); //L/s
// pump hydraulic power with accumulator,
kW_pump_acc=(Q_pump_acc*10^-3*p2*10^5)/1000; //kW
// pump flow-rate without accumulator,
Q_pump_no_acc=V/t; //L/s
// pump hydraulic power without accumulator,
kW_pump_no_acc=(Q_pump_no_acc*10^-3*p3*10^5); //kW

// Results:
printf("\n  Results:  ")
printf("\n The required size of accumulator is %.0f
    L.",V1)
printf("\n The pump hydraulic horsepower with
    accumulator is %.2f kW.",kW_pump_acc)
printf("\n The pump hydraulic horsepower without
    accumulator is %.1f kW.",kW_pump_no_acc)
```

Chapter 17

ADVANCED ELECTRICAL CONTROLS FOR FLUID POWER SYSTEMS

Scilab code Exa 17.1.a determine system accuracy of electrohydraulic system

```
// Aim:To determine the system accuracy of
   electrohydraulic servo system
// Given:
// servo valve gain:
G_SV=0.15; //(in^3/s)/mA
// cylinder gain:
G_cyl=0.20; //in/in^3
// feedback transducer gain:
H=4; //V/in
// weight of load:
W=1000; //lb
// mass of load:
M=2.59; //lb.(s^2)/in
// volume of oil under compression:
V=50; //in^3
// system deadband:
```

```
SD=4; //mA
// bulk modulus of oil:
beta1=175000; //lb/in^2
// cylinder piston area:
A=5; //in^2
```

Scilab code Exa 17.1.b SOLUTION system accuracy of electrohydraulic system

```
clc;
pathname=get_absolute_file_path('17_1_soln.sce')
filename=pathname+filesep()+'17_1_data.sci'
exec(filename)

// Solutions:
// natural frequency of the oil,
om_H=A*sqrt((2*beta1)/(V*M)); //rad/s
// value of open-loop gain,
open_loop=om_H/3; ///s
// amplifier gain,
G_A=open_loop/(G_SV*G_cyl*H); //mA/V
// repeatable error,
RE=SD/(G_A*H); //in

// Results:
printf("\n  Results:  ")
printf("\n The repeatable error of system is %.5f in.",RE)
```

Scilab code Exa 17.2.a determine system accuracy in SI

```
// Aim:To determine the system accuracy of in SI units
```

```
// Given:
// servo valve gain:
G_SV=2.46; //(cm^3/s)/mA
// cylinder gain:
G_cyl=0.031; //cm/cm^3
// feedback transducer gain:
H=4; //V/cm
// mass of load:
M=450; //kg
// volume of oil:
V=819; //cm^3
// system deadband:
SD=4; //mA
// bulk modulus of oil:
beta1=1200; //MPa
// cylinder piston area:
A=32.3; //cm^2
```

Scilab code Exa 17.2.b SOLUTION system accuracy in SI

```
clc;
pathname=get_absolute_file_path('17_2_soln.sce')
filename=pathname+filesep()+'17_2_data.sci'
exec(filename)

// Solutions:
// natural frequency of the oil,
om_H=(A*10^-4)*sqrt((2*beta1*10^6)/(V*10^-6*M)); //rad/s
// value of open-loop gain,
open_loop=om_H/3; ///s
// amplifier gain,
G_A=open_loop/(G_SV*G_cyl*H); //mA/V
// repeatable error,
RE=SD/(G_A*H); //cm
```

```
// rounding off the above answer,
RE=fix(RE)+(fix(ceil((RE-fix(RE))*100000))/100000);
   //cm

// Results:
printf("\n  Results:  ")
printf("\n The repeatable error of system is %.5f cm
   .",RE)
```

Scilab code Exa 17.3.a find maximum tracking error

```
// Aim:Refer Example 14-3 for Problem Description
// Given:
// servo valve current saturation:
I=300; //mA
// amplifier gain:
G_A=724; //mA/V
// feedback transducer gain:
H=4; //V/in
// feedback transducer gain in metric units
H1=1.57; //V/cm
```

Scilab code Exa 17.3.b SOLUTION maximum tracking error

```
clc;
pathname=get_absolute_file_path('17_3_soln.sce')
filename=pathname+filesep()+'17_3_data.sci'
exec(filename)

// Solutions:
// tracking error,
TE=I/(G_A*H); //in
// tracking error,
```

```
TE1=I/(G_A*H1); //cm

// Results:
printf("\n  Results:  ")
printf("\n The tracking error of system is %.3f in."
   ,TE)
printf("\n The tracking error of system in SI Unit
   is %.3f cm.",TE1)
```