

Scilab Textbook Companion for  
Introduction to Thermal Systems Engineering:  
Thermodynamics, Fluid Mechanics, and Heat  
Transfer  
by M. J. Moran<sup>1</sup>

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# Book Description

**Title:** Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer

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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 3

# Using Energy and First Law of thermodynamics

Scilab code Exa 3.1 1

```
1
2 //example 3.1
3 clc; funcprot(0);
4 // Initialization of Variable
5 V1=0.1;
6 V2=0.2;
7 P1=3.0; //pressure
8 n1=1.5;
9 n2=1.0;
10 n3=0.0;
11 P2=P1*(V1/V2)^n1;
12 W=(P2*V2-P1*V1)/(1-n1);
13 disp(W*100,"work done in kj");
14 W2=P1*V1*log(V2/V1);
15 disp(W2*100,"work done in kj");
16 W3=P1*(V2-V1);
17 disp(W3*100,"work done in kj");
18 clear()
```

---

### Scilab code Exa 3.2 2

```
1
2
3 //example 3.2
4 clc; funcprot(0);
5 // Initialization of Variable
6 k=-4.6; //u2-u1;
7 W=17.6; //work done
8 m=4; //mass
9 Q=W+m*k;
10 disp(Q,"Energy transferred in kJ");
11 clear()
```

---

### Scilab code Exa 3.3 3

```
1 //example 3.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 patm=14.7; //in lbf/in^2
5 mpiston=100;
6 g=32.2;
7 A=1; //area
8 mair=0.6;
9 delu=18;
10 k=1.6; //V2-V1;
11 P=mpiston*g/A/32.2/144+14.7;
12 W=P*k*144/778;
13 Q=W+mair*delu;
14 disp(Q,"Heat transferred in Btu")
15 W2=patm*k*144/778;
16 disp(W2,"Work done in Btu");
```

```
17 delz=k/A;
18 PE=mpiston*g*delz/32.2/778;
19 Q2=W2+PE+mair*delu;
20 disp(Q2,"Heat transferred in Btu")
21 clear()
```

---

#### Scilab code Exa 3.4 4

```
1
2 //example 3.4
3 clc; funcprot(0);
4 // Initialization of Variable
5 h=-0.171;
6 A=1;
7 Tb=300;//temperature
8 Tf=293;//temperature
9 W1dot=-60.0;
10 Qdot=h*A*(Tb-Tf);
11 disp(Qdot,"the rate of heat transfer in kW");
12 W2dot=Qdot-W1dot;
13 disp(W2dot,"the rate of energy transfer in kW");
14 clear()
```

---

#### Scilab code Exa 3.5 5

```
1 //example 3.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 Wdot=-0.225;
5 A=25.0e-6;
6 h=150;
7 Tf=293;//temperature
8 Tb=-Wdot/h/A+Tf;
```

```
9 disp(Tb,"temperature in kelvin (80 C)");
10 clear()
```

---

### Scilab code Exa 3.6 6

```
1 //example 3.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 clf()
5 t=linspace(0,100,11);
6 tau=18;
7 omega=100;
8 Wdotelec=-2.0;
9 Wdotshaft=tau*omega/1000;
10 Wdot=Wdotelec+Wdotshaft;
11 Q=0.2*2.71^-(0.05*t);
12 delE=4*(1-2.71^-(0.05*t));
13 plot(t,Q);
14 plot(t,delE,'r');
15 xtitle('Q or delE vs t','time','Q(blue) or delE(red)');
16 clear()
```

---

# Chapter 4

## Evaluating Properties

Scilab code Exa 4.1 1

```
1 //example 4.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 V=0.5; //volume
5 P1=1; //pressure
6 P2=0.5;
7 vf1=1.0432/1000;
8 vf2=1.0582/1000;
9 x=0.5;
10 T1=99.63;
11 v1=vf1+0.5*(1.694-vf1);
12 v2=v1;
13 T2=111.4; //from table
14 disp(T2,"temperature in degree celcius");
15 m=V/v1;
16 mg1=x*m;
17 disp(mg1,"mass of vapor in kg");
18 x2=(v1-vf2)/(1.159-vf2);
19 mg2=x2*m;
20 disp(mg2,"mass of vapor in kg");
21 clear()
```

---

### Scilab code Exa 4.2 2

```
1 //example 4.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 m=0.1;
5 v1=2.2661;
6 P2=20; //pressure
7 v2=2.6704;
8 V1=m*v1;
9 disp(V1,"volume in ft^3");
10 V2=m*v2;
11 disp(V2,"volume in ft^3");
12 W=P2*(V2-V1)*144/778;
13 disp(W,"Work done in Btu");
14 clear()
```

---

### Scilab code Exa 4.3 3

```
1 //example 4.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 V=10.0; //ft^3
5 v1=26.8; //ft^3/lb
6 u1=1077.6; //btu/lb
7 u2=1161.6; //Btu/lb;
8 m=V/v1;
9 W=-m*(u2-u1);
10 disp(W,"Work done in Btu");
11 clear()
```

---

#### Scilab code Exa 4.4 4

```
1 //example 4.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 P=10; //pressure
5 v2=0.1944; //volume
6 v1=0.3066; //volume
7 uf3=631.68;
8 v3=0.1944;
9 vg3=0.3928;
10 vf3=1.0905/1000;
11 x3=(v3-vf3)/(vg3-vf3);
12 u3=uf3+x3*(2559.5-uf3);
13 k1=P*(v2-v1)*100; //k=W/m
14 k2=u3-2957.3+k1; //k2=Q/m
15 disp(k2,"Q/m in kJ/kg");
16 clear()
```

---

#### Scilab code Exa 4.6 6

```
1 //example 4.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 Tr1=793.0/647.3;
5 Pr1=22.0/22.09;
6 Rbar=8314.0;
7 M=18.02;
8 T1=793.0;
9 P1=20.0e6;
10 pr2=0.69;
11 v1=0.83*Rbar/M/P1*T1;
```



```
12 disp(v1," Specific weight in m3/kg");
13 vrdash=v1*22.09e6/Rbar*M/647.3;
14 Tr2=673/647.3;
15 P2=22.09e6*pr2;
16 disp(P2/106," Pressure in Mpa");
17 clear()
```

---

#### Scilab code Exa 4.7 7

```
1 //example 4.7
2 clc; funcprot(0);
3 // Initialization of Variable
4 p2=2; //pressure
5 p1=1; //pressure
6 T1=540; //temperature
7 Rbar=1545;
8 M=28.97;
9 P1=14.7*144;
10 T2=p2/p1*T1;
11 disp(T2,"temperature in degreeR");
12 v3=Rbar/M*T2/P1;
13 disp(v3,"specific volume in ft3/lb");
14 clear()
```

---

#### Scilab code Exa 4.8 8

```
1 //example 4.8
2 clc; funcprot(0);
3 // Initialization of Variable
4 Q=-20;
5 m=2;
6 u2=143.98;
7 u1=92.04;
```

```
8 W=Q-m*(u2-u1);
9 disp(W,"work done on the system in Btu");
10 clear()
```

---

#### Scilab code Exa 4.10 10

```
1 //example 4.10
2 clc; funcprot(0);
3 // Initialization of Variable
4 m1=2;
5 m2=8;
6 T1=350;
7 T2=300;
8 P1=0.7; //bar
9 P2=1.2; //bar
10 Tf=315; //K
11 cv=0.745; //heat capacity
12 pf=(m1+m2)*Tf/(m1*T1/P1+m2*T2/P2);
13 disp(pf,"final pressure in bar");
14 Q=m1*cv*(Tf-T1)+m2*cv*(Tf-T2);
15 disp(Q,"heat transfer into the system in kJ");
16 clear()
```

---

#### Scilab code Exa 4.11 11

```
1 //example 4.11
2 clc; funcprot(0);
3 // Initialization of Variable
4 P2=5.0;
5 P1=1.0;
6 n=1.3;
7 T1=530;
8 R=1.986;
```

```
9 u2=131.88;
10 u1=90.33;
11 T2=T1*(P2/P1)^(.3/n);
12 k1=R*(T2-T1)/(1-n)/28.97; //k1=W/m
13 disp(k1,"W/m in Btu/lb");
14 k2=k1+u2-u1; //k2=Q/m
15 disp(k2,"Q/m in Btu/lb");
16 clear()
```

---

# Chapter 5

## Control Volume Analysis Using Energy

Scilab code Exa 5.1 1

```
1 //example 5.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 v3=1.108e-3;
5 m1dot=40;
6 A2=25.0e-4;
7 v2=1.0078e-3;
8 m3dot=0.06/v3;
9 m2dot=m3dot-m1dot;
10 disp(m2dot,"mass flow rate in kg/s");
11 V2=m2dot*v2/A2;
12 disp(V2,"velocity in m/s");
13 clear()
```

---

Scilab code Exa 5.3 3

```

1 //example 5.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=3213.6; //kJ/kg
5 V1=10.0;
6 V2=665.0;
7 mdot=2.0;
8 h2=h1+(V1^2/2-V2^2/2)/1000;
9 //using table with given h2 values
10 v2=0.1627; //specific volume
11 V2=665;
12 A2=mdot*v2/V2;
13 disp(A2,"Area in m^2");
14 clear()

```

---

#### Scilab code Exa 5.4 4

```

1 //example 5.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=3177.2;
5 x2=0.9;
6 hf2=191.83;
7 mdot=4600.0;
8 Wcvdot=1000.0;
9 V2=50.0; //velocity
10 V1=10.0; //velocity
11 h2=hf2+x2*2392.8;
12 k1=h2-h1;
13 k2=(V2^2/2-V1^2/2)/1000.0;
14 Qcvdot=Wcvdot+mdot*(k1+k2)/3600;
15 disp(Qcvdot,"specific kinetic energy difference in
    kW");
16 clear()

```

---

### Scilab code Exa 5.5 5

```
1 //example 5.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 A1=0.1;
5 V1=6.0;
6 V2=2.0;
7 delh=290.16-451.8;
8 p1=10^5;
9 Rbar=8314.0;
10 Qcvdot=-180.0/60;
11 M=28.97;//molecular mass
12 T1=290.0;
13 mdot=A1*V1*p1*M/Rbar/T1;
14 Wcvdot=Qcvdot+mdot*(delh+(V1^2/2-V2^2/2)/1000);
15 disp(Wcvdot,"heat transfer per unit time in kW")
16 clear()
```

---

### Scilab code Exa 5.7 7

```
1 //example 5.7
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=2465.1;
5 h2=188.45;
6 k=62.7;//h3-h4;
7 k2=(h1-h2)/k;
8 disp(k2,"m3dot/ml1dot is");
9 k3=h2-h1;
10 disp(k3,"Qcvdot/ml1dot in kJ/kg");
11 clear()
```

---

**Scilab code Exa 5.8 8**

```
1 //example 5.8
2 clc; funcprot(0);
3 // Initialization of Variable
4 v1=1.3;
5 cp=1.005;
6 p1=1.01325*10^5;
7 T2=305;
8 T1=293;
9 pi=3.14;
10 Wcvdot=-98.0;
11 A1=1/v1*(-Wcvdot/cp/(T2-T1)/1000)*8314/28.97*T1/p1;
12 D1=sqrt(4*A1/pi)*100;
13 disp(round(D1),"minmum diameter required in cm");
14 clear()
```

---

**Scilab code Exa 5.9 9**

```
1 //example 5.9
2 clc; funcprot(0);
3 // Initialization of Variable
4 hf1=394.1;
5 hg1=1203.9;
6 h2=1168.8;
7 x1=(h2-hf1)/(hg1-hf1);
8 disp(x1*100,"the quality of line in %");
9 clear()
```

---

# Chapter 6

## The Second Law of Thermodynamics

Scilab code Exa 6.1 1

```
1 //example 6.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 Input=1000.0;
5 Tc=300.0;
6 Th=500.0;
7 Output=410.0;
8 neta=Output/Input*100;
9 nmax=(1-Tc/Th)*100;
10 disp(neta,"efficiency in %");
11 disp(nmax,"maximum efficiency in %");
12 disp("the system cannot exist");
13 clear()
```

---

Scilab code Exa 6.2 2



```

1 //example 6.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 Qcdot=8000;
5 Wcycledot=3200.0;
6 Tc=268.0;
7 Th=295.0;
8 Beta=Qcdot/Wcycledot;
9 disp(Beta,"coeff. of performance");
10 Betamax=Tc/(Th-Tc);
11 disp(Betamax,"maximum coeff. of performance");
12 clear()

```

---

### Scilab code Exa 6.3 3

```

1 //example 6.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 Tc=492;
5 Th=530; //temperature
6 Qh=6e5;
7 Wcycle=(1-Tc/Th)*Qh;
8 disp(Wcycle,"Minimum Work input theoretical in Btu/
   day");
9 MTC=Wcycle/3413*0.08;
10 disp(MTC,"Minimum cost theoretical in $/day");
11 clear()

```

---

# Chapter 7

## Using Entropy

Scilab code Exa 7.1 1

```
1 //example 7.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 P=1.014;
5 vg=1.673;
6 vf=1.0435/1000;
7 T=373.15; //temperature
8 sg=7.3549;
9 sf=1.3069;
10 k=P*(vg-vf)*10^5/1000;
11 disp(k,"W/m in kJ/kg");
12 k1=T*(sg-sf);
13 disp(k1,"Q/m in kJ/kg");
14 clear()
```

---

Scilab code Exa 7.2 2

```
1 //example 7.2
```

```
2 clc; funcprot(0);
3 // Initialization of Variable
4 k=-2087.56;//from table t2
5 disp(k,"W/m in kJ/kg");
6 k1=6.048;//from table t2
7 disp(k1,"sigma/m in kJ/kg/K");
8 clear()
```

---

#### Scilab code Exa 7.4 4

```
1 //example 7.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 Qdot=-1.2;
5 Tb=300.0;
6 Tf=293.0;
7 sigmadot=-Qdot/Tb;
8 disp(sigmadot,"heat transfer rate in kW/K");
9 sigmadot1=-Qdot/Tb;
10 disp(sigmadot1,"heat transfer rate in kW/K");
11 clear()
```

---

#### Scilab code Exa 7.5 5

```
1 //example 7.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 k1=540.0;//Wcv/m
5 h2=2676.1;
6 h1=3230.9;
7 V2=100;
8 V1=160;
9 s2=7.3549;
```

```

10 s1=6.9212;
11 k2=k1+(h2-h1)+(V2^2/2-V1^2/2)/1000;
12 disp(k2,"Qcvdot/mdot in kJ/kg");
13 k3=-k2/350+(s2-s1);
14 disp(k3,"sigmaacvdot/mdot in kJ/kg/K");
15 clear()

```

---

### Scilab code Exa 7.6 6

```

1 //example 7.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 T2=635;//temperature
5 T1=530;//temperature
6 T3=460;//temperature
7 P2=1;//pressure
8 P3=1;//pressure
9 P1=5.1;//pressure
10 cp=0.24;
11 R=1.986/28.97;
12 k1=-105;//T1-T2
13 k2=70;//T1-T3
14 a=0.4*k1+0.6*k2;
15 disp(a,"since mass is conserved thus value is ");
16 k=0.4*(cp*log(T2/T1)-R*log(P2/P1))+0.6*(cp*log(T3/T1)
    )-R*log(P3/P1));
17 disp(k,"sigmaacvdot/mldot in Btu/lb/R");
18 disp("thus second law of thermodynamics is also
    conserved");
19 clear()

```

---

### Scilab code Exa 7.8 8

```

1 //example 7.8
2 clc; funcprot(0);
3 // Initialization of Variable
4 p1=1; //pressure
5 pr2=21.18;
6 pr1=1.3860;
7 k=1.39;
8 T2=1160; //temperature
9 T1=540; //temperature
10 p=p1*pr2/pr1;
11 disp(p," pressure in atm");
12 p2=p1*(T2/T1)^(k/(k-1));
13 disp(p2," Pressure final in atm");
14 clear()

```

---

#### Scilab code Exa 7.9 9

```

1 //example 7.9
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=3105.6;
5 h2s=2743.0;
6 nt=0.75; //effeiciency
7 k=nt*(h1-h2s);
8 disp(k," Wcvdot/mdot in kJ/kg");
9 clear()

```

---

#### Scilab code Exa 7.10 10

```

1 //example 7.10
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=390.88;

```

```
5 h2s=285.27;
6 k=74.0; //Wcvdot/mdot
7 ks=h1-h2s; //(Wcvdot/mdot) s
8 nt=k/ks*100;
9 disp(nt," efficiency in %");
10 clear()
```

---

### Scilab code Exa 7.13 13

```
1 //example 7.13
2 clc; funcprot(0);
3 // Initialization of Variable
4 T1=293; //kelvin
5 p2=5; //atm
6 p1=1; //atm
7 n=1.3;
8 h2=426.35;
9 h1=293.17;
10 T2=T1*(p2/p1)^((n-1)/n);
11 k=-n*8.314/28.97*(T2-T1)/(n-1); //Wcvdot/mdot
12 disp(k,"Wcvdot/mdot in kJ/kg");
13 k1=k+h2-h1;
14 disp(k1,"Qcvdot/mdot in kJ/kg");
15 clear()
```

---

# Chapter 8

## Vapor Power and Refrigeration System

Scilab code Exa 8.1 1

```
1 //example 8.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=2758.0;
5 h2=1794.8;
6 h3=173.88;
7 h4=h3+1.0084/1000*(8-0.008)*1000;
8 neta=(h1-h2-h4+h3)/(h1-h4);
9 disp(neta*100,"thermal efficiency in %");
10 bwr=(h4-h3)/(h1-h2);
11 disp(bwr*100,"back work ratio in %");
12 mdot=100*1000*3600/(h1-h2-h4+h3);
13 disp(mdot,"mass flow rate in kg/h");
14 Qindot=mdot*(h1-h4)/3600/1000;
15 disp(Qindot,"energy inflow rate in MW");
16 Qoutdot=mdot*(h2-h3)/3600/1000;
17 disp(Qoutdot,"energy outflow rate in MW");
18 disp(Qoutdot/Qindot*100,"ratio of energy outflow/
    inflow in %");
```

```
19 mcwdot=mdot*(h2-h3)/(146.68-62.99);
20 disp(mcwdot,"mass flow rate in kg/h");
21 clear()
```

---

### Scilab code Exa 8.2 2

```
1 //example 8.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=2758.0;
5 h2=1939.3;
6 h3=173.88;
7 h4=h3+8.06/0.85;
8 neta=(h1-h2-h4+h3)/(h1-h4);
9 disp(neta*100,"thermal efficiency in %");
10 mdot=100*1000*3600/(h1-h2-h4+h3);
11 disp(mdot,"mass flow rate in kg/h");
12 Qindot=mdot*(h1-h4)/3600/1000;
13 disp(Qindot,"energy inflow rate in MW");
14 Qoutdot=mdot*(h2-h3)/3600/1000;
15 disp(Qoutdot,"energy outflow rate in MW");
16 mcwdot=mdot*(h2-h3)/(146.68-62.99);
17 disp(mcwdot,"mass flow rate in kg/h");
18 clear()
```

---

### Scilab code Exa 8.3 3

```
1 //example 8.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=3348.4;
5 h2=2741.8;
6 h3=3353.3;
```



```

7 h4=2428.5;
8 h6=181.94;
9 h5=173.88;
10 neta=(h1-h2-h4+h3-h6+h5)/(h1-h6+h3-h2);
11 disp(neta*100,"thermal efficiency in %");
12 mdot=100*1000*3600/(h1-h2-h4+h3-h6+h5);
13 disp(mdot,"mass flow rate in kg/h");
14 Qoutdot=mdot*(h4-h5)/3600/1000;
15 disp(Qoutdot,"energy outflow rate in MW");
16 //part2
17 h2=2832.8;
18 h4=2567.2;
19 neta=(h1-h2-h4+h3-h6+h5)/(h1-h6+h3-h2);
20 disp(neta*100,"thermal efficiency in %");
21 clear()

```

---

#### Scilab code Exa 8.4 4

```

1 //example 8.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=3348.4;
5 h7=705.3;
6 h6=697.22;
7 h5=174.6;
8 h4=173.88;
9 h2=2832.8;
10 h3=2249.3;
11 k1=h1-h2+0.8034*(h2-h3); //Wt/ml
12 k2=h7-h6+0.8034*(h5-h4); //Wp/ml
13 k3=h1-h7; //Qin/ml
14 neta=(k1-k2)/k3;
15 disp(neta*100,"thermal efficiency in %");
16 m1dot=100*1000*3600/(k1-k2);
17 disp(m1dot,"mass flow rate in kg/h");

```

18 `clear()`

---

#### Scilab code Exa 8.5 5

```
1 //example 8.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 mdot=0.08;
5 h2s=264.7;
6 h1=247.23;
7 h4=85.75;
8 Th=299.0;
9 Wcdot=mdot*(h2s-h1);
10 disp(Wcdot,"work input in kW");
11 Qindot=mdot*(h1-h4)*60.0/211;
12 disp(Qindot,"refrigeration capacity in ton");
13 Beta=(h1-h4)/(h2s-h1);
14 disp(Beta,"coefficient of performance");
15 Bmax=273/(Th-273);
16 disp(Bmax,"maximum coefficient of performance");
17 clear()
```

---

#### Scilab code Exa 8.6 6

```
1 //example 8.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 h2s=272.39;
5 h1=241.35;
6 mdot=0.08;
7 h4=99.56;
8 Wcdot=mdot*(h2s-h1);
9 disp(Wcdot,"work input in kW");
```

```
10 Qindot=mdot*(h1-h4)*60.0/211;
11 disp(Qindot,"refrigeration capacity in ton");
12 Beta=(h1-h4)/(h2s-h1);
13 disp(Beta,"coefficient of performance");
14 clear()
```

---

### Scilab code Exa 8.7 7

```
1 //example 8.7
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=241.35;
5 h2s=272.39;
6 nc=0.8; //efficiency
7 h4=91.49;
8 h2=(h2s-h1)/nc+h1;
9 mdot=0.08;
10 Wcdot=mdot*(h2-h1);
11 disp(Wcdot,"work input in kW");
12 Qindot=mdot*(h1-h4)*60.0/211;
13 disp(Qindot,"refrigeration capacity in ton");
14 Beta=(h1-h4)/(h2-h1);
15 disp(Beta,"coefficient of performance");
16 clear()
```

---

# Chapter 9

## Gas Power Systems

Scilab code Exa 9.1 1

```
1 //example 9.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 T2=1212.0;
5 p1=1.0;
6 T1=540.0;
7 T4=1878.0;
8 T3=3600.0;
9 u4=342.2;
10 u1=92.04;
11 u3=721.44;
12 u2=211.3;
13 m=1.47/1000;
14 V1=0.02;
15 k=8; //V1/V2
16 p2=k*p1*T2/T1;
17 disp(p2," pressure in atm");
18 p3=p2*T3/T2;
19 disp(p3," pressure in atm");
20 p4=p1*T4/T1;
21 disp(p4," pressure in atm");
```

```

22 neta=1-(u4-u1)/(u3-u2);
23 disp(neta*100,"thermal efficiency in %");
24 W=m*(u3-u4-u2+u1);
25 mep=W/V1/(1-1/k)*778/144;
26 disp(mep,"mean effective pressure in lbf/in^2 is
    equal to 8.03 atm");
27 clear()

```

---

### Scilab code Exa 9.2 2

```

1 //example 9.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 T2=898.3;
5 T1=300.0;
6 T4=887.7;
7 vr3=3.97;
8 V1=0.861;
9 R=8314; //gas constant
10 u4=664.3;
11 u1=214.07;
12 h3=1999.1;
13 h2=930.98;
14 p1=0.1;
15 k=18.0; //V1/V2
16 rc=2.0; //V3/V2
17 p2=k*p1*T2/T1;
18 disp(p2,"pressure in atm");
19 T3=rc*T2;
20 disp(T3,"temperature in K");
21 vr4=vr3*k/rc;
22 p4=p1*T4/T1;
23 disp(p4,"pressure in atm");
24 neta=1-(u4-u1)/(h3-h2);
25 disp(neta*100,"thermal efficiency in %");

```

```

26 W=(h3-u4-h2+u1); //Wcycle/m
27 V1=R*T1/29.97/10^5;
28 mep=W/V1/(1-1/k)*1000/10^6;
29 disp(mep,"mean effective pressure in MPa");
30 clear()

```

---

### Scilab code Exa 9.3 3

```

1 //example 9.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 h4=808.5;
5 h2=579.9;
6 h3=1515.4;
7 h1=300.19;
8 T=300; //temperature
9 R=8314; //gas constant
10 M=28.97; //mass molecular
11 neta=(h3-h4-h2+h1)/(h3-h2);
12 disp(neta*100,"thermal efficiency in %");
13 bwr=(h2-h1)/(h3-h4);
14 disp(bwr*100,"back work ratio in %");
15 mdot=5*10^5*M/R/T;
16 Wcycledot=mdot*[h3-h4-h2+h1];
17 disp(Wcycledot,"net power developed in kW");
18 clear()

```

---

### Scilab code Exa 9.4 4

```

1 //example 9.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 h1=300.19;

```

```

5 k=349.6; //Wcdot/mdot
6 h2=h1+k;
7 h3=1515.4;
8 mdot=5.807;
9 k2=h3-h2; //Qindot/mdot
10 neta=(565.6-k)/k2;
11 disp(neta*100,"thermal efficiency in %");
12 bwr=k/565.5;
13 disp(bwr*100,"back work ratio in %");
14 Wcycledot=mdot*(565.5-k);
15 disp(Wcycledot,"net power developed in kW");
16 clear()

```

---

#### Scilab code Exa 9.5 5

```

1 //example 9.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 h3=1515.4; //kJ/kg
5 h4=808.5; //kJ/kg
6 nreg=0.8;
7 h2=579.9; //kJ/kg
8 h1=300.19; //kJ/kg
9 hx=nreg*(h4-h2)+h2;
10 neta=(h3-h4-h2+h1)/(h3-hx);
11 disp(neta*100,"thermal efficiency in %");
12 clear()

```

---

#### Scilab code Exa 9.6 6

```

1 //example 9.6
2 clc; funcprot(0);
3 // Initialization of Variable

```

```
4 ha=102.7; //Btu/lb
5 Va=909.3; // ft /s
6 h3=546.54; //Btu/lb
7 h2=216.2; //Btu/lb
8 pr4=113.8;
9 h5=265.8; //Btu/lb
10 pr3=233.5;
11 h1=102.7+Va^2/2/32.2/778;
12 pr1=1.051;
13 pra=0.6268;
14 p1=pr1/pr4*11.8;
15 disp(p1," Pressure in lbf/in^2");
16 p2=8*p1;
17 disp(p2," Pressure in lbf/in^2");
18 p3=p2;
19 h4=h3+h1-h2;
20 p4=p3*pr4/pr3;
21 disp(p4," Pressure in lbf/in^2");
22 V5=sqrt(2*(h4-h5)*32.2*778);
23 disp(V5," velocity in ft/s (2069 mi/h)");
24 clear()
```

---



# Chapter 10

## Psychrometric Operations

Scilab code Exa 10.1 1

```
1 //example 10.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 phi=0.7;
5 pg=0.3632;//lbf/in^2
6 omega2=0.0052;
7 pv1=phi*pg;
8 omega1=0.622*pv1/(14.7-pv1);
9 disp(omega1,"lb(vapor)/lb(dry air) is");
10 mv1=1/(1/omega1+1);
11 ma=1-mv1;
12 mv2=omega2*ma;
13 mw=mv1-mv2;
14 disp(mw,"mass of water vapor that condenses in lb");
15 clear()
```

---

Scilab code Exa 10.2 2

```

1 //example 10.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 phi1=0.8;
5 pg1=0.01228;
6 pa1=0.9902*10^5;;
7 R=8314; //gasconstant
8 T=283;
9 pv1=phi1*pg1;
10 va1=R/28.97*T/pa1;
11 madot=150/va1;
12 omega=0.622*(pv1/(1-pv1));
13 Qcvdot=madot*(303.2-283.1)+omega*(2556.3-2519.8);
14 disp(Qcvdot,"heat flow rate in kJ/min");
15 pv2=pv1;
16 phi2=pv2/0.04246;
17 disp(phi2*100,"humidity in %");
18 //alternatively
19 madot=150/0.81;
20 Qcvdot=madot*(45.9-25.7);
21 disp(Qcvdot,"heat flow rate in kJ/min");
22 clear()

```

---

### Scilab code Exa 10.3 3

```

1 //example 10.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 pv1=0.02123*10^5;
5 patm=1.013*10^5;
6 ha2=283.1;
7 ha1=303.2;
8 hg1=2556.3;
9 hg2=2519.8;
10 omega2=0.0076;

```

```

11 hf2=42.01;
12 T=303; //temperature
13 R=8314; //gas constant
14 M=28.97; //molecular mass
15 pa1=patm-pv1;
16 madot=280*pa1*M/R/T;
17 disp(madot,"mass flow rate in kg/min");
18 omega1=0.622*pv1/pa1;
19 k=omega1-0.0076;
20 disp(k,"mwdot/madot is (kg/kg)");
21 Qcvdot=madot*((ha2-ha1)-omega1*hg1+omega2*hg2+(
    omega1-omega2)*hf2);
22 disp(Qcvdot,"heat flow rate in kJ/min");
23 clear()

```

---

#### Scilab code Exa 10.4 4

```

1 //example 10.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 omega1=0.002;
5 mstdot=52;
6 madot=90;
7 omega2=omega1+mstdot/60/madot;
8 disp(omega2,"humidity ratio is ");
9 clear()

```

---

#### Scilab code Exa 10.5 5

```

1 //example 10.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 T1=100;

```

```

5 T2=70;
6 cpa=0.24;
7 omega1=0.0045; //humidity
8 hg1=1105;
9 hg2=38.1;
10 hg2=1092;
11 hf=38.1;
12 p2=14.696; //lb/in^2
13 omega2=(cpa*(T1-T2)+omega1*(hg1-hf))/(hg2-hf);
14 mwdot=352.1*60*(omega2-omega1);
15 disp(mwdot,"mass flow rate in lb/h");
16 pv2=omega2*p2/(omega2+0.622);
17 phi2=pv2/0.36332;
18 disp(phi2*100,"relative humidity in %")
19 clear()

```

---

#### Scilab code Exa 10.6 6

```

1 //example 10.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 omega1=0.002;
5 omega2=0.0094;
6 ma1dot=180.0;
7 ma2dot=497.0;
8 omega3=(omega1*ma1dot+omega2*ma2dot)/(ma1dot+ma2dot)
9 ;
10 disp(omega3,"relative humidity");
11 k1=10; //(ha+whv)1
12 k2=47.8; //(ha+whv)2
13 k3=(ma1dot*k1+ma2dot*k2)/(ma1dot+ma2dot)
14 disp(k3,"(ha+whv)3 in kJ/kg");
15 disp(19,"temperature by inspection in degreeC")
16 clear()

```

---

### Scilab code Exa 10.7 7

```
1 //example 10.7
2 clc; funcprot(0);
3 // Initialization of Variable
4 m1dot=4.5e7;
5 hf1=159.21;
6 hf2=125.79;
7 ha4=308.2;
8 ha3=298.2;
9 w4=0.0327; //humidity
10 hg4=2565.3;
11 hg3=2547.2;
12 w3=0.0068; //humidity
13 hf5=83.96;
14 madot=m1dot*(hf1-hf2)/(ha4-ha3+w4*hg4-w3*hg3-(w4-w3)
    *hf5);
15 m5dot=madot*(w4-w3);
16 disp(m5dot,"mass flow rate in kg/h");
17 clear()
```

---

# Chapter 11

## Getting Started in Fluid Mechanics

Scilab code Exa 11.1 1

```
1 //example 11.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 gas=42.5;//gamma of gasoline
5 hgas=17.0;//height of gasoline
6 hw=3.0;//height of water
7 wat=62.4;//gamma of water
8 k=gas*hgas/144.0;//p1-p0
9 disp(k,"pressure difference in lbf/in^2");
10 disp(k*144/wat,"pressure difference in feet of water
    ");
11 k1=wat*hw/144.0+k;//p2-p0
12 disp(k1*144,"pressure difference in lbf/ft^2");
13 disp(k1,"pressure difference in lbf/in^2");
14 disp(k1*144/wat,"pressure difference in feet of
    water");
15 clear()
```

---

### Scilab code Exa 11.2 2

```
1 //example 11.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 SGoil=0.9;//specific gravity of oil
5 wat=62.4;//gamma of water
6 SGhg=13.6;//specific gravity of mercury
7 h1=36.0/12;
8 h2=6.0/12;
9 h3=9.0/12;
10 pair=-SGoil*wat*(h1+h2)+SGhg*wat*h3;
11 pgage=pair/144.0;
12 disp(pgage,"Gauge pressure in lbf/in^2(psi)");
13 clear()
```

---

### Scilab code Exa 11.3 3

```
1 //example 11.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 b=2.0;
5 a=4.0;
6 gamm=9.8*10^3;//gamma
7 pi=3.14;
8 Fr=integrate('gamm*sin(pi*60/180)*b*y','y',6,10);
9 yr=gamm*sin(pi*60/180)/Fr*b*integrate('y^2','y',
    ,6,10);
10 disp(yr,"location of resultant weight in m");
11 //alternatively
12 yr1=b*a^3/12/b/a/8+8;
13 disp(yr1,"location of resultant weight in m");
```

14 `clear()`

---



# Chapter 12

## The Momentum and Mechanical Energy Equations

Scilab code Exa 12.1 1

```
1 //example 12.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 //for a sample value of theta=45degrees
5 pi=3.14;
6 rho=1.94;
7 A=0.06; //area
8 V=10.0; //velocity
9 theta=pi*45/180;
10 Fax=-rho*A*V^2*(1-cos(theta));
11 disp(Fax,"resultant force in x direction in lbf");
12 Fay=rho*A*V^2*sin(theta);
13 disp(Fay,"resultant force in y direction in lbf");
14 clear()
```

---

Scilab code Exa 12.2 2

```

1 //example 12.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 rho=1.94;
5 A=0.1;
6 V=50;
7 p1=30; //pressure
8 p2=24; //pressure
9 mdot=rho*A*V;
10 Fay=-2*mdot*V-(p1+p2)*144*A;
11 disp(Fay,"resultant force in y direction in lbf");
12 disp("resultant force in -ve y direction")
13 clear()

```

---

### Scilab code Exa 12.3 3

```

1 //example 12.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 rho=999.0;
6 Q=0.6/1000;
7 A1=pi*0.016^2/4;
8 A2=pi*0.005^2/4;
9 p1=464*1000;
10 p2=0;
11 Ww=0.03;
12 Wn=1;
13 mdot=rho*Q;
14 V1=Q/A1;
15 V2=Q/A2;
16 Fa=mdot*(V1-V2)+Wn+Ww+p1*A1;
17 disp(Fa,"Force in N");
18 clear()

```

---

### Scilab code Exa 12.5 5

```
1 //example 12.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 k=3.0; //p1/gamma
5 k2=0.5; //p2/gamma
6 z1=0;
7 z2=2;
8 h1=k-k2-z2+z1;
9 disp(h1,"head loss in terms of height of water")
10 clear()
```

---

### Scilab code Exa 12.6 6

```
1 //example 12.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 z1=100;
5 V2=6;
6 g=9.81;
7 gamm=9.8*1000; //density
8 Q=4.72; //flow rate
9 ht=z1-V2^2/2/g;
10 Wtdot=gamm*Q*ht/1000;
11 disp(Wtdot,"power output in kW");
12 clear()
```

---

### Scilab code Exa 12.7 7

```

1 //example 12.7
2 clc; funcprot(0);
3 // Initialization of Variable
4 Wpdot=10*550;
5 gamm=62.4;//density
6 Q=2;//flow rate
7 hp=Wpdot/gamm/Q;
8 hl=-30+hp;
9 disp(hl,"head loss in ft");
10 Wdot=gamm*Q*hl/550;
11 disp(Wdot,"power output in hp");
12 clear()

```

---

#### Scilab code Exa 12.8 8

```

1 //example 12.8
2 clc; funcprot(0);
3 // Initialization of Variable
4 k=1.4;
5 p0=1*10^6;
6 p2=7.84*10^5;
7 k=1.4;
8 R=8314;//gas constant
9 T2=336;//temperature
10 M2=(2/(k-1)*((p0/p2)^((k-1)/k)-1))^0.5;
11 disp(M2,"the exit mach no is");
12 V2=M2*sqrt(k*R/28.97*T2);
13 mdot=p2*V2/1000/R/T2*28.97;
14 disp(mdot,"mass flow rate in kg/s");
15 clear()

```

---

#### Scilab code Exa 12.9 9

```
1 //example 12.9
2 clc; funcprot(0);
3 // Initialization of Variable
4 k1=0.88; //p2/poy;
5 k2=0.628; //poy/pox
6 pox=100; //pressure
7 R=1545;
8 T2=494;
9 k=1.4;
10 M2=0.24;
11 A=2.4;
12 V2=M2*sqrt(k*R/28.97*T2*32.2);
13 mdot=95.9*A*V2/T2/R*28.97;
14 disp(mdot,"mass flow rate in lb/s");
15 p2=k1*k2*pox;
16 disp(p2,"pressure in lbf/in^2")
17 clear()
```

---

# Chapter 14

## Internal and External Flow

Scilab code Exa 14.1 1

```
1 //example 14.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 rho=1.23;//density
5 V=50;//velocity
6 D=0.004;//diameter
7 l=0.1;
8 mu=1.79e-5;
9 Re=rho*V*D/mu;
10 disp(Re,"reynolds no");
11 f=0.028;//friction factor from Moody's chart
12 delP=f*l/D*.5*rho*V^2/1000.0;
13 disp(delP,"pressure difference in kPa");
14 clear()
```

---

Scilab code Exa 14.2 2

```
1 //example 14.2
```

```

2  clc; funcprot(0);
3  // Initialization of Variable
4  rho=1.94;
5  V=8.7;
6  D=0.0625;
7  g=32.2;
8  V2=19.6;
9  l=60;
10 z2=20;
11 mu=2.34e-5;
12 K1=2; //constant
13 Re=rho*V*D/mu;
14 disp(Re,"reynolds no");
15 f=0.0215; //friction factor from Moody's chart
16 P1=rho*g*z2+1/2*rho*(V2^2-V^2)+rho*f*l/D*V^2/2;
17 P1=P1/144+rho*V^2/2*(10+4*1.5+K1)/144;;
18 disp(P1,"entire pressure drop in psi");
19 clear()

```

---

### Scilab code Exa 14.3 3

```

1  //example 14.3
2  clc; funcprot(0);
3  // Initialization of Variable
4  rho=1.67;
5  V=9.31; //velocity
6  D=4;
7  mu=8.0e-5;
8  g=32.2;
9  l=799;
10 Q=117;
11 f=0.0125; //friction factor
12 Re=rho*V*D/mu;
13 disp(Re,"reynolds no");
14 hp=f*l/D*V^2/2/g*5280;

```

```
15 disp (hp, "pump head in ft of H20");
16 hp=round (hp/100)*100
17 W=rho*g*Q*hp/550;
18 disp (W, "power required in hp");
19 clear ()
```

---

#### Scilab code Exa 14.7 7

```
1 //example 14.7
2 clc; funcprot (0);
3 // Initialization of Variable
4 rho=0.00238;
5 U=80.7; //velocity
6 l=8;
7 mu=3.74e-7;
8 Cd=0.0066;
9 d=4;
10 Re=rho*U*l/mu;
11 disp (Re, "reynolds no");
12 f=0.0066; //friction factor from Moody's chart
13 D=1/2*rho*U^2*l*d*f;
14 disp (D, "drag force in lbf");
15 clear ()
```

---

#### Scilab code Exa 14.8 8

```
1 //example 14.8
2 clc; funcprot (0);
3 // Initialization of Variable
4 rho=0.00238;
5 U=93.5; //velocity
6 Cd1=0.55; //coeff of drag
7 A1=5.2*5.1;
```



```

8 D1940=1/2*rho*Cd1*A1*U^2;
9 disp(D1940,"drag force in lbf");
10 A2=5.2*4.3;
11 Cd2=0.3;
12 D2003=1/2*rho*Cd2*A2*U^2;
13 disp(D2003,"drag force in lbf");
14 W1940=D1940*U/550;
15 disp(W1940,"power required to overcome drag force in
    hp");
16 W2003=D2003*U/550;
17 disp(W2003,"power required to overcome drag force in
    hp");
18 clear()

```

---

#### Scilab code Exa 14.9 9

```

1 //example 14.9
2 clc; funcprot(0);
3 // Initialization of Variable
4 A=96*7.5;
5 W=210;
6 rho=2.38e-3;
7 U=15;
8 Cl=2*W/rho/U^2/A;
9 disp(Cl,"coeff. of lift ");
10 clear()

```

---

# Chapter 15

## Getting Started in Heat Transfer

Scilab code Exa 15.1 1

```
1 //example 15.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 k=1.7;
5 delT=250;
6 L=0.15;
7 H=0.5;
8 W=1.2;
9 qx=k*delT/L;
10 qx=H*W*qx;
11 disp(qx,"heat flux in W");
12 clear()
```

---

Scilab code Exa 15.2 2

```
1 //example 15.2
```

```

2  clc; funcprot(0);
3  // Initialization of Variable
4  Ts=473;
5  sigma=5.67e-8;
6  Tsur=298;
7  h=15.0;
8  pi=3.14;
9  D=0.07;
10 epsilon=0.8;//emmisivity
11 E=epsilon*sigma*Ts^4;
12 G=sigma*Tsur^4;
13 disp(G,"irradiation in W/m^2");
14 q=h*pi*D*(Ts-Tsur)+epsilon*pi*D*sigma*(Ts^4-Tsur^4);
15 disp(q,"heat transfer per unit length in W/m");
16 clear()

```

---

#### Scilab code Exa 15.5 5

```

1  //example 15.5
2  clc; funcprot(0);
3  // Initialization of Variable
4  k=1.2;
5  epsilon=0.8;//emmisivity
6  h=20;
7  Ts=373;
8  Tsur=298;
9  sigma=5.67e-8;
10 L=.15;//length
11 a=h*(Ts-Tsur)+epsilon*sigma*(Ts^4-Tsur^4);
12 T1=Ts+L/k*a;
13 disp(T1,"inner wall temperature in K");
14 disp(T1-273,"inner wall temperature in K");
15 clear()

```

---

### Scilab code Exa 15.6 6

```
1 //example 15.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 //solving for Ts
5 Tinfinity=293;
6 Tsurr=303;
7 epsilon=0.5;//emmisivity
8 alpha=0.8;
9 G=2000;
10 h=15;
11 sigma=5.67e-8;
12 deff('y=f(x)', 'y=alpha*G-h*(x-Tinfinity)-epsilon*
      sigma*(x^4-Tsurr^4)');
13 [x]=fsolve(307,f);
14 disp(x,"temperature in K");
15 disp(x-273,"temperature in degree C");
16 clear()
```

---

# Chapter 16

## Heat Transfer by Conduction

Scilab code Exa 16.1 1

```
1 //example 16.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 Tso=50;//temperature
5 Tinfinity=25;//temperature
6 Tsi=385;//temperature
7 ka=0.15;
8 kb=0.08;
9 ho=25;//W/K/m^2
10 La=(Tsi-Tso)/(1/ka+0.5/kb)/(ho*(Tso-Tinfinity));
11 L=La+0.5*La
12 disp(L*1000,"required thickness of composite in mm")
13 ;
14 clear()
```

---

Scilab code Exa 16.2 2

```
1 //example 16.2
```

```

2 clc; funcprot(0);
3 // Initialization of Variable
4 h=100;
5 Tinfinity=25;
6 Pe=10^4;
7 Tc=Tinfinity+Pe*(1/(1/h)+1/(0.9e-4+0.008/238+1/h))
   ^-1;
8 disp(Tc,"allowable maximum temperature in degreeC")
9 clear()

```

---

### Scilab code Exa 16.3 3

```

1 //example 16.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 r1=0.25; //m
5 r2=0.275; //m
6 T1=300;
7 T2=77;
8 k=0.0017;
9 hfg=2.0e5;
10 pi=3.14;
11 q=(T1-T2)/(1/4/pi/k*(1/r1-1/r2)+1/20/4/pi/r2^2);
12 disp(q,"heat transfer in W");
13 mdot=q/hfg;
14 k=mdot/804*1000*3600*24;
15 disp(k,"mdot/rho in liters/day")
16 clear()

```

---

### Scilab code Exa 16.4 4

```

1 //example 16.4
2 clc; funcprot(0);

```

```

3 // Initialization of Variable
4 Tinfinity=30;
5 q=1.5e6;
6 La=0.05;
7 h=1000;
8 T2=Tinfinity+q*La/h;
9 disp(T2,"temperature in degreeC");
10 T1=Tinfinity+(0.02/150+1/h)*q*La;
11 To=q*La^2/2/75+T1;
12 disp(To,"inner surface temperature in degreeC");
13 clear()

```

---

#### Scilab code Exa 16.6 6

```

1 //example 16.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 h=100; //W/m^2/K
6 P=pi*0.005;
7 k=398;
8 Ac=pi/4*0.005^2;
9 thetab=100-25;
10 qf=(h*P*k*Ac)^0.5*thetab;
11 disp(qf,"heat rate in copper rod in W");
12 L=2.65*(k*Ac/h/P)^0.5*1000;
13 disp(L,"minimum value of the length in mm");
14 clear()

```

---

#### Scilab code Exa 16.7 7

```

1 //example 16.7
2 clc; funcprot(0);

```

```

3 // Initialization of Variable
4 pi=3.14;
5 T1=80;
6 Tinfinity=20; //temperature
7 Rtc1=1e-3; //m2K/W
8 r1=0.002;
9 r2=0.003;
10 H=0.006;
11 k=200;
12 Rtb=638; //K/W
13 Rtf12=24.4;
14 Rtc=Rtc1/2/pi/r1/H;
15 Rtsleeve=log(r2/r1)/2/pi/H/k;
16 Requiv=(1/Rtf12+1/Rtb)^-1;
17 Rtot=Rtc+Rtsleeve+Requiv;
18 qt=(T1-Tinfinity)/Rtot
19 disp(qt,"heat transfer rate in W");
20 clear()

```

---

### Scilab code Exa 16.8 8

```

1 //example 16.8
2 clc; funcprot(0);
3 // Initialization of Variable
4 D=0.125;
5 h=25; //W/m^2
6 k=1.4;
7 c=835; //J/kg
8 Tinfinity=20; //degreeC
9 Ti=225; //degreeC
10 t=360;
11 rho=2225; //density
12 Lc=D/6;
13 Tt=Tinfinity+(Ti-Tinfinity)*exp(-h*t/rho/Lc/c);
14 disp(Tt,"temperature after 6 min in degreeC");

```



```
15 clear()
```

---

#### Scilab code Exa 16.9 9

```
1 //example 16.9
2 clc; funcprot(0);
3 // Initialization of Variable
4 rho=2770;
5 L=0.0015;
6 epsilon=0.8; //emmisivity
7 Tavg=360.5;
8 Tsur=448;
9 sigma=5.67e-8;
10 c=875; //J/kg-K
11 tc=rho*L*c/(40+12)*log((25-175)/(150-175));
12 te=tc+5*60;
13 disp(te,"total time spent in s");
14 hrad=epsilon*sigma*(Tavg+Tsur)*(Tavg^2+Tsur^2);
15 disp(hrad,"radiation energy in W/m^2-K");
16 clear()
```

---

#### Scilab code Exa 16.10 10

```
1 //example 16.10
2 clc; funcprot(0);
3 // Initialization of Variable
4 h=100; //W/m^2
5 L=0.025;
6 c=800;
7 rho=2325; //density
8 k=1.0;
9 Tinfinity=175;
10 Ti=25;
```

```
11 alpha=5.38e-7;
12 t=60*10;
13 theta=0.615;
14 Bi=h*L/k;
15 disp(Bi," Biot number is");
16 Fo=alpha*t/L^2;
17 disp(Fo," Fourier number is");
18 T10=Tinfinity+theta*(Ti-Tinfinity);
19 disp(T10," midplane temperature after 10 min degreeC"
);
20 tstar=theta*cos(1.1347);
21 Tl10=Tinfinity+tstar*(Ti-Tinfinity);
22 disp(Tl10," msurface temperature after 10 min degreeC"
);
23 ql=h*(Tl10-Tinfinity);
24 disp(ql," heat transfer in W/m^2");
25 Q=rho*c*0.509*L*(Ti-Tinfinity);
26 disp(Q," Energy per unit surface in J/m^2")
27 clear()
```

---

# Chapter 17

## Heat transfer by Convection

Scilab code Exa 17.1 1

```
1 //example 17.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 k=integrate('x^-0.1','x',0,1);
5 disp(k,"ratio of average convection coefficient");
6 clear()
```

---

Scilab code Exa 17.2 2

```
1 //example 17.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 U=10;//m/s
5 L=0.5;
6 nu=30.84e-6;
7 Pr=0.687;//prandtl number
8 Re=U*L/nu;
9 disp(Re,"reynolds number");
```

```

10 Nu1=0.664*Re^0.5*Pr^0.33;
11 h=Nu1*0.0364/L;
12 q=h*L*(300-27);
13 disp(q,"colling rate in W/m");
14 //if there is turbulence
15 Nu1=0.037*Re^0.8*Pr^0.33;
16 h1=Nu1*0.0364/L;
17 q1=h1*L*(300-27);
18 disp(q1,"colling rate in W/m in turbulence");
19 clear()

```

---

### Scilab code Exa 17.3 3

```

1 //example 17.3
2 clc; funcprot(0);
3 // Initialization of Variable
4 u=60; //m/s
5 Nu5=546;
6 nu=26.41e-6;
7 L4=0.2;
8 L5=0.25;
9 Pr=0.69;
10 Re4=u*L4/nu;
11 Re5=u*L5/nu;
12 Nu4=0.664*Re4^0.5*Pr^0.33;
13 h14=Nu4*0.0338/L4;
14 Nu4=0.664*Re5^0.5*Pr^0.33;
15 h15=Nu5*0.0338/L5;
16 qconv=(h15*L5-h14*L4)*(230-25);
17 disp(qconv,"heat transfer rate in W");
18 clear()

```

---

### Scilab code Exa 17.4 4

```

1 //example 17.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 Ts=128.4;
6 Tinfinity=26.2;
7 k=0.03;
8 D=0.0127; //m
9 Re=6071; //reynold's no
10 Pr=0.7;
11 qconv=46;
12 A=pi*0.0127*0.094;
13 h=0.85*qconv/A/(Ts-Tinfinity);
14 disp(h,"heat transfer coefficient in W/m^2-K");
15 Nu=0.3+0.62*Re^0.5*Pr^0.33/(1+0.4^0.66*Pr^0.66)
    ^0.25*(1+(Re/282000)^0.625)^0.8;
16 hbar=Nu*k/D;
17 disp(Nu,"Nusselt no is")
18 disp(hbar,"heat transfer coefficient in W/m^2-K");
19 //using Hilpert correlation
20 Nu1=0.193*Re^0.618*Pr^0.333;
21 disp(Nu1,"Nusselt no is");
22 hbar1=Nu1*k/D;
23 disp(hbar1,"heat transfer coefficient in W/m^2-K");
24 clear()

```

---

#### Scilab code Exa 17.5 5

```

1 //example 17.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 Ti=75;
5 k=0.02588;
6 D=0.01;
7 Nu=47.4

```

```

8 rho=8933; // density
9 c=387;
10 D=0.01;
11 Tinfinity=23;
12 T=35;
13 h=Nu*k/D;
14 t=rho*c*D/6/h*log((Ti-Tinfinity)/(T-Tinfinity));
15 disp(t,"cooling time required in s");
16 Bi=h*0.005/3/399;
17 disp(Bi,"Biots number")
18 clear()

```

---

#### Scilab code Exa 17.6 6

```

1 //example 17.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 m=0.1;
5 cp=4179; //J/kg/K
6 q=10^6; //W/m^3
7 Do=0.04;
8 Di=0.02;
9 pi=3.14;
10 L=4*m*cp/(Do^2-Di^2)/pi/q*(60-20);
11 disp(L,"tube length in m");
12 Re=4*m/pi/Di/6.57e-4;
13 disp(Re,"reynolds number");
14 qs=q*(Do^2-Di^2)/4/Di;
15 ho=qs/(70-60);
16 disp(ho,"local heat coefficient in W/m^2-K");
17 clear()

```

---

#### Scilab code Exa 17.7 7

```

1 //example 17.7
2 clc; funcprot(0);
3 // Initialization of Variable
4 m=0.25; //kg/s
5 cp=4178; //J/kg-K
6 Tmo=57;
7 Tmi=15;
8 pi=3.14;
9 D=0.05; //m
10 L=6; //m
11 delT=(-Tmo+Tmi)/log((100-Tmo)/(100-Tmi));
12 h=m*cp/pi/D/L*(Tmo-Tmi)/delT;
13 disp(h,"average convection coefficient in W/m^2-K");
14 clear()

```

---

#### Scilab code Exa 17.9 9

```

1 //example 17.9
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 qs=2000;
6 cp=4181;
7 m=0.01;
8 D=0.06;
9 k=0.67;
10 Nu=4.36;
11 L=m*cp/pi/0.06/qs*(80-20);
12 disp(L,"tube length in m");
13 h=Nu*k/D;
14 Ts=qs/h+80;
15 disp(Ts,"surface temperature in degreeC");
16 clear()

```

---

### Scilab code Exa 17.10 10

```
1 //example 17.10
2 clc; funcprot(0);
3 // Initialization of Variable
4 m=2; //kg/s
5 D=0.04; //m
6 mu=695*10^-6; //Ns/m^2;
7 pi=3.14;
8 Nu=396; //nusselt number
9 Re=4*m/pi/D/mu;
10 disp(Re,"reynolds number");
11 h=Nu*0.628/D;
12 Tmo=95-(95-25)*exp(-pi*D*h/m/4178*4);
13 disp(Tmo,"temperature in degree c");
14 q=m*4176*(Tmo-25);
15 disp(q/1000,"rate of heat transfer in kW");
16 Nu1=0.027*Re^0.8*4.62^0.33;
17 disp(Nu1,"Nusselt number");
18 h1=Nu1*0628/D;
19 disp(h1/1000,"coefficient of heat transfer in W/m-K"
    );
20 clear()
21 clear()
```

---

### Scilab code Exa 17.11 11

```
1 //example 17.11
2 clc; funcprot(0);
3 // Initialization of Variable
4 k=33.8e-3;
5 L=0.71;
```



```

6 A=1.02*0.71; // area
7 Ts=505; // temperature
8 Tsur=296 // temperature
9 Nu=147;
10 h=Nu*k/L;
11 q=h*A*(Ts-Tsur);
12 disp(q,"heat transfer by convection in W");
13 qrad=A*5.67e-8*(Ts^4-Tsur^4);
14 disp(qrad,"heat transfer by radiation in W");
15 hrad=5.67e-8*(Ts+Tsur)*(Ts^2+Tsur^2);
16 disp(hrad,"linearized radiation coefficient in W/m^2-
    K");
17 clear()

```

---

#### Scilab code Exa 17.12 12

```

1 //example 17.12
2 clc; funcprot(0);
3 // Initialization of Variable
4 Nu=65.8;
5 k=0.028;
6 As=1.2*1.2; // area
7 Ts=350; // temperature
8 Tsurr=300; // temperature
9 sigma=5.67e-8;
10 epsilon=0.25; // emmissivity
11 h=Nu*k/0.3;
12 Pe=h*As*(Ts-Tsurr)+epsilon*sigma*As*(Ts^4-Tsurr^4);
13 disp(Pe,"allowable electrical power in W");
14 clear()

```

---

#### Scilab code Exa 17.13 13

```

1 //example 17.13
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 D=0.1;
6 Nu=23.3;
7 k=0.0313;
8 Ts=438; //temperature
9 Tsurr=296; //temperature
10 sigma=5.67e-8;
11 epsilon=0.85; //emmisivity
12 h=Nu*k/D;
13 q=h*pi*D*(Ts-Tsurr)+epsilon*sigma*pi*D*(Ts^4-Tsurr
    ^4);
14 disp(q,"heat transfer rate from the pipe in W/m");
15 clear()

```

---

#### Scilab code Exa 17.14 14

```

1 //example 17.14
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 k=0.625;
6 D=0.025;
7 Nu=90;
8 ho=40;
9 q=8524;
10 delT=(59.8-30)/log(59.8/30);
11 hi=Nu*k/D;
12 U=1/(1/hi+1/ho);
13 L=q/(U*pi*D*delT);
14 disp(L,"length of exchanger in m");
15 clear()

```

---

Scilab code Exa 17.15 15

```
1 //example 17.15
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 q=7.317e5;
6 c=2350;
7 Thi=160;
8 Thd=100;
9 delT=(75-85)/log(75/85);
10 mh=q/c/(Thi-Thd);
11 disp(mh,"mass flow rate of oil in kg/s");
12 ho=400;
13 k=0.643;
14 D=0.025; //diameter
15 Nu=119;
16 hi=k/D*Nu;
17 U=1/(1/hi+1/ho);
18 L=q/(U*pi*D*delT*10*0.87);
19 disp(L,"length of exchanger in m");
20 clear()
```

---

# Chapter 18

## Heat transfer by radiation

Scilab code Exa 18.1 1

```
1 //example 18.1
2 clc; funcprot(0);
3 // Initialization of Variable
4 G1=600; //G1=Glambda
5 alpha=0.85;
6 G=G1*(2.5-1)*0.5+G1*0.5*(0.5)+G1*(1.0-0.5);
7 disp(G,"total radiation in W/m^2");
8 Gabs=alpha*G;
9 disp(Gabs,"absorbed radiation in W/m^2");
10 J=0.15*G+525;
11 disp(J,"total radiosity");
12 qrad=525-Gabs;
13 disp(qrad,"net radiative flux leaving the surface in
    W/m^2");
14 clear()
```

---

Scilab code Exa 18.2 2

```

1 //example 18.2
2 clc; funcprot(0);
3 // Initialization of Variable
4 sigma=5.67e-8;
5 lambda1=2200;//mum
6 T=2000;//K
7 C1=3.742e8;//mum^4/m^2
8 C2=1.439e8;
9 lambdamax=1.45;//mum
10 E=sigma*T^4;
11 disp(E,"spectral emmusive power in W/m^2");
12 lambda=lambda1/T;
13 disp(lambda,"wavelength corresponding to upper limit
    in mum");
14 E=C1/lambdamax^5/(exp(C2/lambdamax/T)-1);
15 disp(E,"emissive power in W/m^2.mum");
16 disp("G=9.07*10^5 in W/m^2");
17 clear()

```

---

#### Scilab code Exa 18.4 4

```

1 //example 18.4
2 clc; funcprot(0);
3 // Initialization of Variable
4 F1=0.318;//F0---2 mum
5 F2=0.856;//F0---5 mum
6 sigma=5.67e-8;
7 T=1600;//kelvin
8 epsilon=0.4*F1+0.8*(F2-F1);
9 disp(epsilon,"emmisivity");
10 E=epsilon*sigma*T^4;
11 disp(E/1000,"total emmusive power in kW/m^2");
12 clear()

```

---

### Scilab code Exa 18.5 5

```
1 //example 18.5
2 clc; funcprot(0);
3 // Initialization of Variable
4 F=0.738; //F0—11 ' mum
5 F1=0.014; //F0—11 mum
6 sigma=5.67e-8;
7 Ts=300;
8 Tf=1200;
9 alpha=0.8*F+0.1*(1-F);
10 disp(alpha,"total absorvity")
11 epsilon=0.8*F1+0.1*(1-F1);
12 disp(epsilon,"emmisivity");
13 qrad=epsilon*sigma*Ts^4-alpha*sigma*Tf^4;
14 disp(qrad/1000,"total emissice power in kW/m^2");
15 disp("epsilon=alpha=0.62 for final condition");
16 clear()
```

---

### Scilab code Exa 18.6 6

```
1 //example 18.6
2 clc; funcprot(0);
3 // Initialization of Variable
4 plambda=0.05;
5 sigma=5.67e-8;
6 T=300; //K
7 epsilon=1-plambda;
8 qrad=epsilon*sigma*T^4-0.226*1353;
9 disp(qrad,"net radiative heat flux leaving in W/m^2"
);
10 clear()
```

---

Scilab code Exa 18.7 7

```
1 //example 18.7
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 F12=0.5;
6 A1=4; //area in terms of L
7 A2=2*pi/4; //area in terms of L
8 F21=A1/A2*F12;
9 disp(F21,"reciprocity relation between A1 and A2");
10 //part2
11 F12=1;
12 A1=1/16; //area in terms of D
13 A2=1/2; //area in terms of D
14 F21=A1/A2*F12;
15 disp(F21,"reciprocity relation between A1 and A2");
16 //part3
17 F22=0.5;
18 F23=1-F21-F22;
19 disp(F23,"reciprocity relation");
20 //part4
21 F13=0.17;
22 F12=1-F13;
23 A1=1/4; //area in terms of D
24 A2=1; //area in terms of D
25 F21=A1/A2*F12;
26 disp(F21,"reciprocity relation between A1 and A2");
27 clear()
```

---

Scilab code Exa 18.8 8

```

1 //example 18.8
2 clc; funcprot(0);
3 // Initialization of Variable
4 pi=3.14;
5 sigma=5.67e-8;
6 T1=1623//K
7 T2=1923;//K
8 T3=300;//K
9 F23=0.06;
10 A2=pi*0.075^2/4;
11 A1=pi*0.075*0.15;
12 F21=1-F23;
13 F12=A2/A1*F21;
14 Pe=A1*0.118*sigma*(T1^4-T3^4)+A2*F23*sigma*(T2^4-T3
    ^4);
15 disp(Pe,"Electrical power required in W");
16 clear()

```

---

### Scilab code Exa 18.9 9

```

1 //example 18.9
2 clc; funcprot(0);
3 // Initialization of Variable
4 sigma=5.67e-8;
5 D1=0.02;
6 D2=0.05;
7 D3=0.035;
8 pi=3.14;
9 T1=77;
10 T2=300;
11 qwo=(sigma*pi*D1*(T1^4-T2^4))/(1/0.02+(1-0.05)
    /0.05*(D1/D2));
12 disp(qwo,"heat rate per unit length in W/m");
13 Rtot=(1-0.02)/(0.02*pi*D1)+1/pi/D1+2*(1-0.02/(0.02*
    pi*D3))+1/pi/0.035+(1-0.05)/pi/D2^2);

```



```
14 qw=sigma*(T1^4-T2^4)/1817;
15 disp(qw,"heat rate of radiation in W/m");
16 k=(qw-qwo)/qwo*100;
17 disp(k,"percentage change of heat transfer in %");
18 clear()
```

---

### Scilab code Exa 18.10 10

```
1 //example 18.10
2 clc; funcprot(0);
3 // Initialization of Variable
4 e1=0.8;
5 e2=0.4;
6 T1=1200;
7 T2=500;
8 A=1;
9 Jr=(108323+59043)/2;
10 sigma=5.67e-8;
11 q1=sigma*(T1^4-T2^4)/((1-e1/e1/A)+1/(A*0.5+(2+2)^-1)
    +(1-e2)/e2/A);
12 disp(q1/1000,"the rate of energy supply in kW/m");
13
14 Tr=(Jr/sigma)^0.25;
15 disp(Tr,"temperature in radiating surface in K");
16 clear()
```

---