

Scilab Textbook Companion for  
Utilization of Electrical Energy and Traction  
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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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# List of Scilab Codes

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# Chapter 1

## Electric heating

Scilab code Exa 1.1 power drawm

```
1 //Example 1.1 power drawm
2 clc;
3 clear;
4 close;
5 format('v',6)
6 r1=100;//in ohms
7 r2=r1;// in ohms
8 V=250;// ac supply in volts
9 rp=((1)/((1/r1)+(1/r2)));// equivalent resistance in
   ohms
10 pp=((V^2)/rp);//power drawn in watts
11 disp("part (a) ")
12 disp(pp,"power drawn when elements are in parallel ,(
   W)=")
13 rs=r1+r2;// equivalent resistance in ohms
14 ps=((V^2)/rs);//power drawn in watts
15 disp("part (b) ")
16 disp(ps,"power drawn when elements are in series ,(W
   )=")
```

---

**Scilab code Exa 1.2** diameter and length of wire

```
1 //Example 1.2 // diameter and length
2 clc;
3 clear;
4 close;
5 format('v',6)
6 P=2.5; //power in kW
7 V=240; // in volts
8 K=1; //radiating efficiency
9 e=0.9; //emissivity
10 p=42.5*10^-6; // resistivity in ohm-cm
11 T1=1500; //in degree celsius
12 T2=450; //in degree celsius
13 x=((%pi*V^2)/(4*(p*10^-2)*P*10^3)); //
14 H=((5.72*K*e)*(((T1+273)/100)^4-((T2+273)/100)^4));
    //
15 z=((P*10^3)/(%pi*H))^2; //
16 l=(z*x)^(1/3); //length in meter
17 d=(sqrt(z)/l)*10^3; //diameter in mm
18 disp(l,"length in meter")
19 disp(d,"diameter in mm")
```

---

**Scilab code Exa 1.3** design the heating element

```
1 //Example 1.3 // design heating element
2 clc;
3 clear;
4 close;
5 format('v',7)
6 V=440; // volts
7 P=20; //in kW
```

```

 8 T1=1200; //in degree celsius
 9 T2=700; // in degree celsius
10 K=0.6; //radiating efficiency
11 e=0.9; //emissivity
12 t=0.025; //thickness in mm
13 p=1.05*10^-6; //resisitivity in ohm - meter
14 Pp=(round(P*10^3))/3; //power per phase in watts
15 Pv= (V/sqrt(3)); //phase voltage
16 R=Pv^2/Pp; //resistance of strip in ohms
17 x=((R*t*10^-3)/(p)); //
18 H=((5.72*K*e)*(((T1+273)/100)^4-((T2+273)/100)^4));
    //in W/m^2
19 y=((Pp)/(H*2)); //in m^2
20 w=sqrt(y/x)*10^3; //width in mm
21 l=x*w*10^-3; //length of strip in meter
22 disp(w,"width in mm")
23 disp(l,"length of strip in meter")

```

---

#### Scilab code Exa 1.4 efficiency

```

1 //Example 1.4 // loading in kW and efficiency of the
   tank
2 clc;
3 clear;
4 close;
5 format('v',5)
6 a=6; //area in m^2
7 l=a/6; //one side of tank in meter
8 V=1*1*1; //volume in m^2
9 e=90/100; //capacity
10 wh=6*e*1000; //water to be heated daily in kg
11 s=4200; //specific heat of water in J/Kg/degree
    celsius
12 t1=65; //in degree celsius
13 t2=20; //in degree celsius

```

```

14 hr=wh*s*(t1-t2)*10^-6; //heat required to raise the
    tempeurture of water
15 hr1=hr/3.6; //heat required in kWh
16 d=6.3; //difference in watts
17 l=((d*a*(t1-t2)*24)/1000); //losses from the surface
    of the tank in kWh
18 es=hr1+l; //energy supplied in kWh
19 lk=es/24; //loading in kW
20 ef=(hr1/es)*100; //efficiency of the tank in
    percentage
21 disp(lk,"loading in kW")
22 disp(ef,"efficiency of the tank in percentage")

```

---

#### Scilab code Exa 1.5 average kW and kVA and pf

```

1 //Example 1.5 // average kW ,KVA input ,arc voltage
    ,arc resistance and pf of the current drawn
2 clc;
3 clear;
4 close;
5 format('v',7)
6 sh=444; // specific heat of steel in J/Kg/ C
7 lh=37.25; //latent heat in kJ/kg
8 mp=1370; //melting point of steel C
9 t1=19.1; //initial tempeurture in C
10 e=0.5; //overall efficiency
11 ip=5700; //input current in amperes
12 rs=0.008; //resistance of transformer referred to
    secondary in ohms
13 rr=0.014; // recatance in ohms
14 m=4.3; // steel in tonnes
15 ers=((m*10^3*((sh*(mp-t1))+lh*10^3))); // energy
    required in joules
16 ersh=ers/(3.6*10^6); //energy required in kWh
17 ata=1; //time taken to melt steel in hours

```

```

18 ao=ersh/ata; //average output in kW
19 ai=ao/e; //average input in kW
20 vdr=ip*rs; //voltage drop due to resistance of
    furnace leads
21 vdr1=ip*rr; //voltage drop due to reactance of
    furnace leads
22 va=((ai*10^3)/(3*ip))-(vdr); //voltage resistive in
    nature
23 rac=va/ip; //arc resistance in
24 oppv=sqrt((va+vdr)^2+vdr1^2); //open circuit phase
    voltage in volts
25 kvas=3*ip*oppv*10^-3; //total kVA drawn
26 pf=((va+vdr)/oppv); //power factor
27 disp(ai,"average input in kW")
28 disp(va,"arc voltage in volts")
29 disp(rac,"arc resistance in ")
30 disp(pf,"pf of the current drawn from the supply (
    lagging)")
31 disp(kvas,"total kVA drawn in kVA")

```

---

### Scilab code Exa 1.6 average kW and kVA and pf

```

1 //Example 1.6 // average kW ,KVA input ,arc voltage
    ,arc resistance and pf of the current drawn
2 clc;
3 clear;
4 close;
5 format('v',7)
6 sh=0.12; // specific heat of steel in kcal/Kg/ C
7 lh=8.89; //latent heat in kcal/kg
8 mp=1370; //melting point of steel C
9 t1=19.1; //initial temperture in C
10 e=0.5; //overall efficiency
11 ip=5700; //input current in amperes
12 rs=0.008; //resistance of transformer referred to

```

```

        secondary in ohms
13 rr=0.014; // reactance in ohms
14 m=4.3; // steel in tonnes
15 ers=((m*10^3*((sh*(mp-t1))+lh))); // energy required
        in joules
16 ersh=ers/(860); //energy required in kWh
17 ata=1; //time taken to melt steel in hours
18 ao=ersh/ata; //average output in kW
19 ai=ao/e; //average input in kW
20 vdr=ip*rs; //voltage drop due to resistance of
        furnace leads
21 vdr1=ip*rr; //voltage drop due to reactance of
        furnace leads
22 va=((ai*10^3)/(3*ip))-(vdr); //voltage resistive in
        nature
23 rac=va/ip; //arc resistance in
24 oppv=sqrt((va+vdr)^2+vdr1^2); //open circuit phase
        voltage in volts
25 kvas=3*ip*oppv*10^-3; //total kVA drawn
26 pf=((va+vdr)/oppv); //power factor
27 disp(ai,"average input in kW")
28 disp(va,"arc voltage in volts")
29 disp(rac,"arc resistance in ")
30 disp(pf,"pf of the current drawn from the supply (
        lagging)")
31 disp(kvas,"total kVA drawn in kVA")

```

---

#### Scilab code Exa 1.7 rating

```

1 //Example 1.7 // rating of furnance
2 clc;
3 clear;
4 close;
5 format('v',6)
6 sh=0.1; // specific heat of steel in kcal/Kg/ C

```

```

7 lh=26.67; //latent heat in kcal/kg
8 mp=555; //melting point of steel C
9 t1=35; //initial temperture in C
10 e=0.8; //overall efficiency
11 ip=5700; //input current in amperes
12 rs=0.008; //resistance of transformer referred to
    secondary in ohms
13 rr=0.014; // recatance in ohms
14 m=2; // steel in tonnes
15 ers=((m*10^3*((sh*(mp-t1))+lh))); // energy required
    in joules
16 ersh=ers/(860); //energy required in kWh
17 ata=1; //time taken to melt steel in hours
18 ao=ersh/ata; //average output in kW
19 ai=ao/e; //average input in kW
20 vdr=ip*rs; //voltage drop due to resistance of
    furnace leads
21 vdr1=ip*rr; //voltage drop due to reactance of
    furnace leads
22 va=((ai*10^3)/(3*ip))-(vdr); //voltage resistive in
    nature
23 rac=va/ip; //arc resistance in
24 oppv=sqrt((va+vdr)^2+vdr1^2); //open circuit phase
    voltage in volts
25 kvas=3*ip*oppv*10^-3; //total kVA drawn
26 pf=((va+vdr)/oppv); //power factor
27 rf=ai/ata; // in kW
28 disp(rf,"rating of furnance in kW")

```

---

Scilab code Exa 1.8 efficiency

```

1 //Example 1.8 // efficiency of furnance
2 clc;
3 clear;
4 close;

```

```

5  format('v',3)
6  sh=880; // specific heat of steel in J/Kg/ C
7  lh=32000; //latent heat in J/kg
8  mp=660; //melting point of steel C
9  t1=15; //initial temperture in C
10 ip=5700; //input current in amperes
11 rs=0.008; //resistance of transformer referred to
    secondary in ohms
12 rr=0.014; // recatance in ohms
13 m=1.8; // IN KG
14 ers=((m*((sh*(mp-t1))+lh))); // energy required in
    joules
15 ersh=ers/(3.6*10^6); //energy required in kWh
16 TM=10; //TIME TO MELT IN MINS
17 ip=5; //input of the furnance in kW
18 ei=(ip)*(TM/60); //energy input in kWh
19 n=(ersh/ei)*100; //efficiency of furnance in
    percentage
20 disp(n,"efficiency of furnance in percentage")

```

---

### Scilab code Exa 1.9 power absorbed and power factor

```

1  //Example 1.9 // power absorbed and power factor
2  clc;
3  clear;
4  close;
5  format('v',8)
6  vs=10; //secondary voltage in volts
7  p=500; //power drawn in kW
8  pf=0.5; //
9  is=(p*10^3)/pf; //secondary current in amperes
10 zs=vs/is; //impedence of secondary circuit in ohms
11 rs=zs*pf; //resistance of secondary circuit in ohms
12 res=zs*(sqrt(1-pf^2)); //rectancetance of secondary
    circuit in ohms

```



```

13 rs1=2*rs; // resistacne when hearth is full in
14 res1=res; // reactance when hearth is full in
15 zs1=(sqrt(rs1^2+res1^2)); //impedance of secondary
    circuit in
16 pf1=rs1/zs1; //power factor
17 is1=vs/zs1; //secondary current in amperes
18 pd=is1^2*rs1*10^-4; //power drawn in kW
19 disp(pf1,"power factor is")
20 disp(pd,"power drawn in kW")

```

---

#### Scilab code Exa 1.10 height

```

1 //Example 1.10 // height
2 clc;
3 clear;
4 close;
5 format('v',8)
6 vs=10; //secondary voltage in volts
7 p=400; //power drawn in kW
8 pf=0.6; //
9 is=(p*10^3)/pf; //secondary current in amperes
10 zs=vs/is; //impedence of secondary circuit in ohms
11 rs=zs*pf; //resistance of secondary circuit in ohms
12 res=zs*(sqrt(1-pf^2)); //rectancetance of secondary
    circuit in ohms
13 x=(rs)/res; //height
14 disp(x,"maximum heat will be obtained with the
    height of charge as 3/4 of height of hearth")

```

---

#### Scilab code Exa 1.11 frequency

```

1 //Example 1.11 // frequency
2 clc;

```

```

3 clear;
4 close;
5 format('v',5)
6 p=5*10^-7; //specific resistance in -m
7 rp=1; //relative permeability
8 dp=0.0015; //depth of penetration in mter
9 f=((p*10^7)/((rp*(dp)^2)*4*(%pi)^2))*10^-3; //
    frequency in kHz
10 disp(f,"frequency in kHz")

```

---

#### Scilab code Exa 1.12 power required

```

1 //Example 1.12 // power required
2 clc;
3 clear;
4 close;
5 format('v',10)
6 l=0.5; //length in meter
7 b=0.25; //breadh in meter
8 h=0.02; //in meter
9 t1=25; // temperture C
10 t2=125; // temperture C
11 t=10; //time in minutes
12 f=30; //frequency in 30 MHz
13 w=600; //weight of the wood in kg/m^3
14 sh=1500; //specific heat in J/Kg/ C
15 e=50; //efficiency
16 vp=l*b*h; //volume in m^3
17 wp=vp*w; //weight of plywood in kg
18 hr=sh*wp*(t2-t1); //heat required in joules
19 hrt=(hr/(3600)); //heat required to raise the
    temperature of plywood in Wh
20 pu=hrt/(1/6); //power utilized in watts
21 pi=(pu/e)*100; //power input required in percentage
22 disp(pi,"power input required ,(W)=")

```

---

**Scilab code Exa 1.13** voltage and current

```
1 //Example 1.13 //voltage ,current and frequency
2 clc;
3 clear;
4 close;
5 format('v',5)
6 v1=600;//in volts
7 p=200;//power absorbed in watts
8 pf=0.05;//power factor
9 f=30*10^6;//frequency in Hz
10 ep=8.854*10^-12;//constant
11 er=5;//
12 a=150;// in cm^2
13 t=0.02;// in meter
14 c=((ep*er*a*10^-4)/t);//capacitance in farads
15 vr=(sqrt(p/(2*pi*f*c*pf)));//voltage is required in
    volts
16 i=p/(vr*pf);//current in amperes
17 f2=((f*(vr/v1)^2))*10^-6;//frequency in Mhz
18 disp(ceil(vr),"voltage in volts")
19 disp(round(i),"current in amperes")
20 disp(f2,"frequency in MHz")
```

---

**Scilab code Exa 1.14** voltage and current

```
1 //Example 1.14//voltage across electrodes and
    current
2 clc;
3 clear;
4 close;
```

```

5 format('v',6)
6 pf=0.04; //power factor
7 p=1000; //in watts
8 f=10*10^6; // in MHz
9 a1=.004; //area in m^2
10 a2=0.001; //area in m^2
11 t=0.02; //thickness in meter
12 t1=.01; //thicknes sin meter
13 t2=t-t1; //thickness in meter
14 ep=8.854*10^-12; //constant in F/m
15 er=5; //relative permittivity of plywood
16 er1=1; //relative permittivity in air
17 c=(ep*(((a1*er1)/t)+(a2/((t1/er)+(t2/er1))))); //
    capacitance in farads
18 vr=(sqrt(p/(2*pi*f*c*pf))); //voltage is required in
    volts
19 disp(" part (a)")
20 disp(round(vr)," voltage across the electrodes in
    volts")
21 i=p/(vr*pf); //current in amperes
22 disp(" part (b)")
23 disp(i," cureent in amperes is")

```

---

# Chapter 3

## Electrolytic processes

Scilab code Exa 3.1 ampere hours

```
1 //Example 3.1 // ampere hour required
2 clc;
3 clear;
4 close;
5 //given data :
6 r=5;//in cm
7 S=4*%pi*r^2;
8 t=0.005;//in mm
9 d=10.5;
10 m=S*t*d*10^-3;
11 Z=(0.001118*3600)/1000;
12 Amr=m/Z;
13 disp(Amr,"ampere hour required ,(Ampere-hour)= ")
```

---

Scilab code Exa 3.2 amount of copper

```
1 //Example 3.2 // mass of copper deposited
2 clc;
```

```

3 clear;
4 close;
5 //given data :
6 m=20; //in gm
7 I=120; //in A
8 t=10*60; //in sec
9 t1=5*60; //in sec
10 I1=100; //in A
11 Cec=63.18/2;
12 Cen=58.6/2;
13 Z=m/(I*t);
14 Z1=(Z*(Cec/Cen))*10-3;
15 m1=Z1*I1*t1;
16 disp("mass of copper deposed is "+string(m1)+" kg
      or "+string(round(m1*103))+ "gm")

```

---

### Scilab code Exa 3.3 weight of copper

```

1 //Example 3.3 // mass of copper deposited
2 clc;
3 clear;
4 close;
5 //given data :
6 Z=1.044*10-8; //in kg/C
7 I=40; //in A
8 t=1*60*60; //in seconds
9 m1=Z*I*t;
10 disp("mass of copper deposed is "+string(m1)+" kg
      or "+string((m1*103))+ "gm")

```

---

### Scilab code Exa 3.4 thickness

```

1 //Example 3.4 // thickness of copper deposited

```

```

2  clc;
3  clear;
4  close;
5  //given data :
6  A=0.00025; //in m^2
7  D=8900; //in kg/m^3
8  Z=32.95*10^-8; //in kg/C
9  I=1; //in A
10 t=100*60; //in seconds
11 m=Z*I*t; //in kg
12 v=m/D;
13 T=(v/A)*10^3;
14 disp(T,"thickness of copper deposited ,T(mm) = ")

```

---

#### Scilab code Exa 3.5 thickness

```

1  //Example 3.5 // thickness of copper deposited
2  clc;
3  clear;
4  close;
5  //given data :
6  A=0.00025; //in m^2
7  D=8900; //in kg/m^3
8  Z=32.95*10^-8; //in kg/C
9  I=1.5; //in A
10 t=60*60; //in seconds
11 m=Z*I*t; //in kg
12 v=m/D;
13 T=(v/A);
14 disp("Thickness of copper deposited is "+string(T)+"
      m or "+string(T*10^3)+"mm")

```

---

#### Scilab code Exa 3.6 current

```

1 //Example 3.6 // current
2 clc;
3 clear;
4 close;
5 //given data :
6 m=50; // in gm
7 t=2*60*60; // in sec
8 ECE_silver=111.8*10^-8; // in kg C^-1
9 atomic_weight1=108; // for silver
10 atomic_weight2=63.5; //for copper
11 valency=1; //for silver
12 Ces=atomic_weight1/valency; // chemical equivalent of
    silver
13 Cec=atomic_weight2/2; // chemical equivalent of
    copper
14 Z=ECE_silver*(Cec/Ces);
15 I=(m*10^-3)/(Z*t);
16 disp(I," current ,I(A) = ")

```

---

### Scilab code Exa 3.7 energy consumption

```

1 //Example 3.7 // energy consumption
2 clc;
3 clear;
4 close;
5 //given data :
6 a=500; // electrolytic cells
7 I=6000; //in A
8 t=40; //in hour/week
9 Z=32.81*10^-8*3600; //in kg/A-h
10 V=0.25; // in volts
11 Ah=a*I*(t*52); // total number of ampere hour per
    annum
12 Ao=Z*Ah*10^-3; // annual output in tonnes
13 Ea=Ah*V*10^-3; // energy consumed per annum in kWh

```



```
14 Et=Ea/Ao;  
15 disp(Et,"energy consumption ,Et(kWh/tonne) = ")
```

---

#### Scilab code Exa 3.8 voltage

```
1 //Example 3.8 // voltage  
2 clc;  
3 clear;  
4 close;  
5 //given data :  
6 Z=1.0384*10^-8;//in kg/C  
7 VbyZ=14.212*10^7;// in joules  
8 V=VbyZ*Z;  
9 disp(V,"voltage ,V( volts) = ")
```

---

#### Scilab code Exa 3.9 WEIGHT OF ALUMINIUM

```
1 //Example 3.9 // mass of aluminium  
2 clc;  
3 clear;  
4 close;  
5 //given data :  
6 ECE_silver=111*10^-8;//in kg/C  
7 Cew_silver=107.98;//chemical equivalent of silver  
8 Cew_al=27/3;//chemical equivalent of aluminium  
9 Z=(ECE_silver*Cew_al)/Cew_silver;  
10 C_efficiency=0.92;  
11 I=3000;//in A  
12 t=24*60*60;//in seconds  
13 m=Z*I*t*C_efficiency;  
14 disp(m,"mass of aluminium , ,m(kg) = ")
```

---

Scilab code Exa 3.10 quantity of electricity and ime taken

```
1 //Example 3.10 // quantity of electricity and time
   taken
2 clc;
3 clear;
4 close;
5 //given data :
6 d=0.1;//in m
7 l=.25;// in m
8 Tc=2;// thickness of coating in mm
9 D=8.9;//density of metal in gm/CC
10 C_density=160;//in A/sq
11 I_efficiency=0.9;
12 S=%pi*d*l;
13 m=S*Tc*10^-3*D*10^3;
14 Z=30.43*10^-8;// in kg/C
15 Q=(m/Z)/3600;// in A-h
16 Q_dash=Q/I_efficiency;
17 disp(Q_dash,"quantity of electricity ,Q_dash(A-h) = "
   )
18 I=C_density*S;
19 t=Q_dash/I;
20 disp(t,"time required ,t(hours) = ")
```

---

# Chapter 4

## Illumination

Scilab code Exa 4.1 MSCP

```
1 //Example 4.1 //MSCP
2 clc;
3 clear;
4 close;
5 format('v',3)
6 F=1000;//intensity in lumens
7 MSCP=F/(4*%pi);// MSCP of the lamps
8 disp(MSCP,"MSCP of the lamp is")
```

---

Scilab code Exa 4.2 lumens per watt and MSCP

```
1 //Example 4.2 //LUMES PER WATT AND MSCP
2 clc;
3 clear;
4 close;
5 format('v',4)
6 V=250;//in volts
7 I=0.8;//in amperes
```

```

8 F=3000; //intensity in lumens
9 wl=V*I; //wattage of lamps in watts
10 lpw=F/wl; // lumens per watt is
11 MSCP=F/(4*pi); // MSCP of the lamps
12 MW=MSCP/wl; //MSCP per watt
13 disp(lpw,"lumens per watt is")
14 disp(MW,"MSCP per watt of the lamp is")

```

---

#### Scilab code Exa 4.3 average luminance

```

1 //Example 4.3 //average luminance of the sphere
2 clc;
3 clear;
4 close;
5 format('v',6)
6 d=0.4; //diameter in meter
7 p=0.20; //in percentage absorption
8 F=4850; // lumens
9 Fe=(1-p)*F; // flux emitted by the globe in lumens
10 sa=4*pi*(d/2)^2; //surface area in m^2
11 als=Fe/sa; //average luminance of sphere in lumens/m
    ^2
12 disp(als,"average luminance of sphere in lumens/m^2
    ")

```

---

#### Scilab code Exa 4.4 Illumination

```

1 //Example 4.4 //illumination
2 clc;
3 clear;
4 close;
5 format('v',7)
6 P=20; //filament power in watts

```

```

7 h=5; //height in meters
8 d=4; //diamter in meter
9 p=0.50; //in percentage absorption
10 ef=0.89; //efficiency in watts
11 cpl=P/ef; //candle power of lamp in CP
12 Lop=4*pi*cpl; //lu,inous output in lumens
13 Fe=(1-p)*Lop; // flux emitted by the globe in lumens
14 sa=%pi*(d/2)^2; //surface area in m^2
15 als=Fe/sa; //average lumninance of sphere in lumens/m
    ^2
16 disp(als," average lumninance of sphere in lumens/m^2
    ")

```

---

#### Scilab code Exa 4.5 average intensity of Illumination

```

1 //Example 4.5 //AVERAGE INTENSITY
2 clc;
3 clear;
4 close;
5 format('v',6)
6 cpl=100; //
7 h=5; //in meter
8 th=60; //in degree
9 F=1000; //intensity in lumens
10 MSCP=F/(4*pi); // MSCP of the lamps
11 ai=((cpl/h^2)*cosd(90-th)); //average intensity of
    illumination
12 disp(round(MSCP),"MSCP of a lamp is,=")
13 disp(ai," average intensity of illumination is lux ")

```

---

#### Scilab code Exa 4.7 Illumination and lamp efficiency

```

1 //Example 4.7 //lamp efficiency and illumination

```

```

2  clc;
3  clear;
4  close;
5  format('v',7)
6  p=500; //lamp power in watts
7  mscp=1250; //
8  h=2.7; //in meters
9  ea=(mscp)/(h)^2; //illumination directly below lamp
    in lux
10 le=(4*pi*mscp)/p; //lamp efficiency in lumens/watts
11 h1=3; //meters
12 eb=((mscp)/(h^2)*(2.7^3/(h1^2+h^2)^(3/2))); //
    illumination at a point 3 meters away on the
    horizontal plane vertically below the lamp in lux
13 disp(ea,"illumination directly below lamp in lux")
14 disp(le,"lamp efficiency in lumens/W")
15 disp(eb,"illumination at a point 3 meters away on
    the horizontal plane vertically below the lamp in
    lux")

```

---

#### Scilab code Exa 4.8 height and Illumination

```

1  //Example 4.8// height and illumination
2  clc;
3  clear;
4  close;
5  format('v',7)
6  l=100; //illumination at a point directly below the
    lamp in lumens/m^3
7  cp=256; //
8  h1=1.2; //in meters
9  h=sqrt(cp/l); //height in meters
10 x=sqrt(h^2+h1^2); //
11 x1=h/x; //
12 eb=((cp)/(h^2))*(x1)^3; //illumination at a point

```

```

    1.2 meters away on the horizontal plane
    vertically below the lamp in lux
13 disp(h,"height in meters is")
14 disp(eb,"illumination at a point 1.2 meters away on
    the horizontal plane vertically below the lamp
    in lux")

```

---

#### Scilab code Exa 4.9 candle power

```

1 //Example 4.9//candle power of lamp
2 clc;
3 clear;
4 close;
5 format('v',7)
6 L1=500;//candle power
7 h1=9;//in meters
8 d=2;//distance in meters
9 I2=20;//illumination in Lux
10 x=sqrt(h1^2+d^2);//from pythagoras theoram
11 Cpx=((I2-(L1/h1^2))*h1^2)/((h1/x)^3);//candle power
12 disp(Cpx,"candle power of lamp two in CP")

```

---

#### Scilab code Exa 4.10 distance

```

1 //Example 4.10//distance
2 clc;
3 clear;
4 close;
5 format('v',5)
6 h1=10;//in meters
7 eL=1;//ASSUME
8 Ea=1/(10)^2;//
9 X((((10^3)*eL)/10^2)*10*(1/Ea);

```

```

10 x=(X)^(2/3);//
11 y=sqrt(x-100);//
12 disp(y,"distance in meters is")

```

---

**Scilab code Exa 4.11** total light flux and average Illumination

```

1 //Example 4.11 //total flux and average luminane of
  the sphere
2 clc;
3 clear;
4 close;
5 format('v',6)
6 th=15;//in degree
7 l=400;//candela
8 d=8;// meter
9 p=0.80;//in percentage absorbtion
10 Fe=p*4*%pi*l;// flux emitted by the globe in lumens
11 dA=d*tand(th/2);//diameter in degree
12 sa=%pi*(dA)^2;//surface area in m^2
13 als=Fe/sa;//average lumninance of sphere in lux
14 disp(Fe,"total flux in lumens")
15 disp(als,"average lumninance of sphere in lux")

```

---

**Scilab code Exa 4.12** maximum and minimum Illumination

```

1 //Example 4.12 //maximum and minimum illumination
2 clc;
3 clear;
4 close;
5 format('v',5 )
6 CP=1000;//
7 h=12;//in meter
8 d=24;//diamter in meter

```



```

9 mil=CP/(h)^2; //maximum illumination in lux
10 mal=mil*(12/sqrt(12^2+12^2))^3; //minimum
    illumination in lux
11 disp(mil,"maximum illumination in lux")
12 disp(mal,"minimum illumination in lux")

```

---

### Scilab code Exa 4.13 Illumination

```

1 //Example 4.13//illumination
2 clc;
3 clear;
4 close;
5 format('v',5 )
6 p=60; //
7 CP=200; //
8 h=6; //in meter
9 d=10; //diamter in meter
10 mil=CP/(h)^2; //maximum illumination in lux
11 disp("part (a). ")
12 disp(mil," illumination at the centre of the area
    without reflector in lux")
13 mal=mil*(h/sqrt(h^2+(d/2)^2))^3; //minimum
    illumination in lux
14 t1=4*pi*CP; //total lumens
15 ts=(p/100)*t1; //total lumens reaching the surface
16 A=%pi*(d/2)^2; //total surface area in m^2
17 alf=ts/A; //average illumination with reflector
18 x=sqrt(h^2+(d/2)^2); //
19 y=h/x; //
20 om=2*pi*(1-y); // in steradians
21 tfr=CP*om; //total flux reaching the surface
22 alwr=tfr/A; //average illumination without reflector
23 disp("part (b). ")
24 disp(mal," illumination at the edge of the area
    without reflector in lux")

```

```

25 disp(alf,"average illumination with reflector in lux
    ")
26 disp(alwr,"average illumination without reflelctor
    in lux")
27 //with the reflector the illumintaion at the edge
    and at the end will be the same since the
    reflection directs the light uniformity on the
    surface

```

---

#### Scilab code Exa 4.14 Illumination

```

1 //Example 4.14 //illumination under each lamp and
    midway between lamps
2 clc;
3 clear;
4 close;
5 format('v',5 )
6 CP=100;//
7 h=6;//in meter
8 d=16;// meter
9 x=sqrt(h^2+d^2);//
10 em=2*((CP/h^2)*(h/(d-h))^3);//illumination in the
    middle in lux
11 ee=((CP/h^2)*(1+(h/x)^3));//illumination iunder each
    lamp in lux
12 disp(ee,"illumination under each lamp in lux")
13 disp(em,"illumination in the middle in lux")

```

---

#### Scilab code Exa 4.15 Illumination

```

1 //Example 4.15 //illumination under each lamp and
    midway between lamps
2 clc;

```

```

3 clear;
4 close;
5 format('v',7 )
6 CP=800; //
7 h=10; //in meter
8 d=12; // meter
9 x=sqrt(h^2+d^2); //
10 x1=sqrt(h^2+(d/2)^2); //
11 em=((CP/h^2)*(1+(h/x)^3+(h/x)^3)); //illumination
    iunder each lamp in lux
12 ee=2*((CP/h^2)*(h/x1)^3); //illumination at the
    centrelamp in lux
13 disp(em,"illumination under each lamp in lux")
14 disp(ee,"illumination in the middle in lux")

```

---

#### Scilab code Exa 4.16 Illumination

```

1 //Example 4.16 //illumination midway between lamps
2 clc;
3 clear;
4 close;
5 format('v',5 )
6 CP=400; //
7 h=10; //in meter
8 d=20; // meter
9 x=sqrt(d^2-h^2); //
10 ee=4*((CP/h^2)*(h/x)^3); //illumination at the
    centrelamp in lux
11 disp(ee,"illumination in the middle in lux")

```

---

#### Scilab code Exa 4.17 spacing

```

1 //Example 4.17//distance

```

```

2  clc;
3  clear;
4  close;
5  format('v',5)
6  cp=500; //cp
7  h=4; //in meter
8  x=((2*cp*h^3)/h^2); //
9  y=((cp*h^3)/h^2); //
10 y1=cp/h^2; //
11 y2=y/2; //
12 y21=y1/2; //
13 d=sqrt((((x-y2)/y21)^(2/3))-h^2)*2.29; //
14 disp(d,"distance is ,(m)=")

```

---

#### Scilab code Exa 4.18 wattage

```

1  //Example 4.18//wattage of lamp
2  clc;
3  clear;
4  close;
5  format('v',6)
6  d=6; //in meter
7  h=4; //in meter
8  ef=20; //lumens per watt
9  uc=0.5; //utilization coefficient
10 il=750; // in lux
11 a=(%pi/4)*(d)^2; //
12 F=a*il; //in lumens
13 tf=F/uc; //total flux emitted by the lamp
14 watt=tf/ef; //wattage of lamp
15 disp(watt,"wattage of lamp in watts")

```

---

#### Scilab code Exa 4.19 candle power

```

1 //Example 4.19// candle power
2 clc;
3 clear;
4 close;
5 v1=220;//voltage of lamp
6 w1=60;//wattage of lamp
7 w11=75;//in watts
8 v2=440;// in volts
9 r1=((v1^2)/w1);// in ohms
10 r2=((v1^2)/w11);// in ohms
11 i=(v2/(r1+r2));//in amperes
12 v1=i*r1;// volts
13 v12=i*r2;//in volts
14 cp6=(ceil(v1)/v1)^4 *(100);//candle power
15 cp7=(v12/v1)^4*(100);//candle power
16 disp(ceil(cp6),"potential drop across 60 watt lamps
    in volts")
17 disp(v12,"potential drop across 75 watt lamps in
    volts")
18 disp(round(cp6),"candle power of 60 watts lampe in
    percentage")
19 disp(cp7,"candle power of 75 watts lampe in
    percentage")
20 //answer is wrong in the book

```

---

#### Scilab code Exa 4.20 capacitance

```

1 //Example 4.20// capacitance
2 clc;
3 clear;
4 close;
5 w=84;//watts
6 pf=0.7;//power factor
7 v=240;//in volts
8 i=(w)/(v*pf);// in amperes

```

```

9 rva=v*i*sqrt(1-pf^2); //relative volt-amperes
10 cpf=1; //corrected power factor
11 rvas=v*i*sqrt(1-cpf^2); //
12 f=50; // in hertz
13 c=((rva)/(2*pi*f*(v)^2)); //in farads
14 disp(c*10^6,"capacitance in (micro-F) is")

```

---

**Scilab code Exa 4.21** compare diameter and length

```

1 //Example 4.21//compare diameter and length
2 clc;
3 clear;
4 close;
5 format('v',6)
6 v1=110; //in volts
7 cp1=16; //in cp
8 cp2=25; //in cp
9 v2=220; //in volts
10 ri=((cp1/cp2)*(v2/v1)); //ratio of curents
11 dr=(ri)^(2/3); //ratio of diameters
12 di=(cp1/cp2)*(1/dr); //ratio of lengths
13 disp(dr,"ratio of diameter is")
14 disp(di,"ratio of length is")

```

---

**Scilab code Exa 4.22** constants and change of candle power per volt

```

1 //Example 4.22//constants and change of candle power
  per volt
2 clc;
3 clear;
4 close;
5 format('v',9)
6 c1=71.5; //candel power

```

```

7 v1=260; //in volts
8 c2=50; //candel power
9 v2=240; //in volts
10 b=log(c1/c2)/(log(v1/v2)); //
11 a=c2/(v2)^(4.5); //
12 disp(" part (a). ")
13 disp(" constants are "+string(a)+" and "+string(b)+"
      ")
14 v=250; // in volts
15 p=4; //change in percentage
16 dvc=a*b*((v)^(b-1)); //in candle per volts
17 dc=(1+(p/100))^b; //when voltage increase by 4%
18 pcp=((dc-1))*100; //percentage change in candle power
19 dc1=(1-(p/100))^b; //when voltage falls by 4%
20 pcp1=((dc1-1))*100; //percentage change in candle
    power
21 disp(" part (b).")
22 disp(dvc," change of candle power per volts")
23 //chage in candle power per volt is calculated wrong
    in the book
24 disp(pcp," percentage change in candle power when
    voltage increase by 4%")
25 disp(pcp1," percentage change in candle power when
    voltage falls by 4%")

```

---

#### Scilab code Exa 4.23 average Illumination

```

1 //Example 4.23//average illumination
2 clc;
3 clear;
4 close;
5 format('v',5)
6 dp=1.2; //depreciation factor
7 uf=0.6; //utiliazation factor
8 l=15; // in meters

```

```

9 b=6; // in meters
10 n=20; // no. of lamps
11 lw=250; // mscp in watts
12 a=l*b; //arean in m^2
13 t1=n*lw*4*%pi; ///total lumens
14 lwp=((t1*uf)/dp); //lumens reaching on the working
    plane
15 e=lwp/a; //illumination on working plane in lux
16 disp(e,"illumination on working plane in lux")

```

---

**Scilab code Exa 4.24** number location and wattage

```

1 //Example 4.24//number ,loaction and wattage
2 clc;
3 clear;
4 close;
5 format('v',5)
6 ef=40; //efficiency in lumens/watt
7 mil=80; // minimum illumination in lumens/m^2
8 dp=0.8; //depreciation factor
9 uf=0.4; //utiliazation factor
10 l=100; // in meters
11 b=10; // in meters
12 a=l*b; //arean in m^2
13 t1=a*mil; ///total lumens
14 glr=t1/(uf*dp); //gross illumination required
15 twr=glr/ef; //total wattage required
16 disp(42,"number of lamps of 150watt rating in 2 rows
    ")
17 disp(twr,"total wattage in watts")

```

---

**Scilab code Exa 4.25** number rating and dipsotion of lamps



```

1 //Example 4.25//number ,rating and disposition of
  lamps
2 clc;
3 clear;
4 close;
5 format('v',6)
6 h=4;//in meters
7 wp=75;//in lux
8 ef=14;//efficiency in lumens/watt
9 dp=0.2;//depreciation factor
10 uf=0.5;//utiliazation factor
11 l=72;// in meters
12 b=15;// in meters
13 a=l*b;//arean in m^2
14 mf=1-dp;//maintenance factor
15 glr=(a*wp)/(uf*mf);//gross illumination required
16 twr=glr/ef;//total wattage required
17 wec=twr/80;//wattage of each lamps
18 disp(80,"number of lamps of 150watt rating in 2 rows
  ")
19 disp(" wattage of each lamp "+string(wec)+" watts
  equivalent to 200 watts")

```

---

**Scilab code Exa 4.26** number rating and dipsotion of lamps

```

1 //Example 4.26//number ,rating and disposition of
  lamps
2 clc;
3 clear;
4 close;
5 a=30*30;//
6 e=75;//
7 uf=0.5;//
8 df=1-0.2;//
9 le=15;//efficiency

```

```

10 ph=(a*e)/(uf*df); //
11 W=ph/le; //
12 ew=300; //W
13 N=W/ew; //
14 disp(N,"total number of lamps is ,= (say 42)")
15 disp(W,"wattage of lamps is ,(W)=")

```

---

**Scilab code Exa 4.27** number and wattage

```

1 //Example 4.27//number and wattage
2 clc;
3 clear;
4 close;
5 format('v',6)
6 h=5; // in meters
7 el=100; //in lux
8 ef=16; //efficiency in lumens/watt
9 dp=0.2; //depreciation factor
10 uf=0.4; //utiliazation factor
11 l=60; // in meters
12 b=15; // in meters
13 a=l*b; //arean in m^2
14 glr=(a*el)/(uf*(1-dp)); //gross illumination required
15 n=12*3; //total no. of
16 twr=glr/ef; //total wattage required
17 wec=twr/n; //wattage of each lamp
18 disp(n,"number of lamps of 150watt rating in 2 rows"
)
19 disp(" wattage of each lamp "+string(wec)+" watts
equivalent to 500 watts")

```

---

**Scilab code Exa 4.28** number spacing height and totl wattge

```

1 //Example 4.28//number ,spacing ,mounting height and
   total wattafe
2 clc;
3 clear;
4 close;
5 format('v',6)
6 h=5; // in meters
7 e1=120; //in lux
8 ef=40; //efficiency in lumens/watt
9 tw=80; //in watts
10 df=1.4; //depreciation factor
11 uf=0.5; //utiliazation factor
12 l=30; // in meters
13 b=15; // in meters
14 a=l*b; //arean in m^2
15 glr=(a*e1*df)/(uf); //gross lumens required
16 twr=glr/ef; //total wattage required
17 nt=twr/tw; //no. of tubes required
18 disp(twr,"total wattage required in watts")
19 disp(" number of tubes required is "+string(nt)+"
   equivalent to 48 tubes")

```

---

**Scilab code Exa 4.29** space height ratio

```

1 //Example 4.29//number of lamps
2 clc;
3 clear;
4 close;
5 format('v',6)
6 e1=50; //in lux
7 df=1.3; //depreciation factor
8 uf=0.5; //utiliazation factor
9 l=30; // in meters
10 b=12; // in meters
11 a=l*b; //arean in m^2

```

```

12 glr=(a*e1*df)/(uf); //gross lumens required
13 watt=[100,200,300,500,1000];
14 lum=[1615,3650,4700,9950,21500]; //
15 for i=1:5
16     n(i)=glr/(lum(i)); //
17     disp("if "+string(watt(i))+ " watt lamps are used
           then number of lamps required is "+string(
           round(n(i)))+ " ")
18
19 end

```

---

#### Scilab code Exa 4.30 Illumination

```

1 //Example 4.30//illumination on surface
2 clc;
3 clear;
4 close;
5 format('v',6)
6 ef=17.4; //in lumens/watt
7 dp=1.2; //depreciation factor
8 wlf=1.3; //waste light factor
9 uf=0.4; //utiliazation factor
10 l=50; // in meters
11 b=16; // in meters
12 n=16; // no. of lamps
13 lw=1000; // mscp in watts
14 a=l*b; //arean in m^2
15 tl=n*lw*ef; ///total lumens
16 lwp=((tl*uf)/(wlf*dp)); //lumens reaching on the
    working plane
17 e=lwp/a; //illumination on the surface in lumens/m^2
18 disp(e,"illumination on the surface in lumens/m^2")

```

---

### Scilab code Exa 4.31 number and size

```
1 //Example 4.31//size and number of projector
2 clc;
3 clear;
4 close;
5 format('v',6)
6 watt=[300,500,1000,1500];
7 lum=[5000,9000,18000,27000];//
8 el=50;// in lux
9 dp=0.8;//depreciation factor
10 wlf=0.5;//waste light factor
11 uf=1.2;//utiliazation factor
12 l=60;// in meters
13 b=15;// in meters
14 lw=1000;// mscp in watts
15 a=l*b;//arean in m^2
16 tl=a*el//total lumens
17 lwp=((tl*uf)/(wlf*dp));//lumens reaching on the
    working plane
18 n = lwp/lum(2);//number of projector required
19 ang=2*atand(4.5/8);//size
20 disp(ceil(n+1),"number of projectors are,=")
21 disp(watt(2)," wattage is ,(W)=")
22 disp(ceil(ang+1),"beam angle is ,(degree)=")
23 disp(""+string(round(n)+1)+ " projectors of "+string
    (watt(2))+ " watts each with beam angle of "+
    string(round(ang+1))+ " degree will be required")
```

---

# Chapter 5

## Refrigeration and Air conditioning

Scilab code Exa 5.1 power

```
1 //Example 5.1: Power
2 clc;
3 clear;
4 close;
5 //given data :
6 t1=20;// in degree C
7 t2=5;// in degree C
8 T=t1-t2;
9 A=3000;// volume of air to be conditioned in m^3
10 Ht=1220;// in J
11 H1=A*Ht*T;
12 m=1000; // per m^3
13 H1=2450*10^3;// latent heat in J/kg
14 w=5;; // in kg
15 M=(w*A)/m;
16 H2=T*H1;//in J
17 H=(H1+H2);
18 P=round(H/(3600*1000));
19 disp(P,"Power required ,(kW) = ")
```

---

**Scilab code Exa 5.2** rating of heater

```
1 //Example 5.2: Rating of Heater
2 clc;
3 clear;
4 close;
5 //given data :
6 t1=25;// in degree C
7 t2=5;// in degree C
8 T=t1-t2;
9 A=6*5*4*(60/15);// volume of air to be conditioned
   in m^3/hour
10 Ht=1220;// in J
11 H1=A*Ht*T;
12 m=1000; // per m^3
13 Hl=836*10^3;// heat loss in J/C/h
14 H2=T*Hl;//in J/hour
15 H=(H1+H2);
16 Rh=round(H/(3600*1000));
17 disp(Rh,"Rating of heater ,(kW) =")
```

---

# Chapter 7

## Train Movement and Energy Consumption

Scilab code Exa 7.1 distance average speed and scheduled speed

```
1 //Example 7.1.//distance ,average speed and scheduled
   speed
2 clc;
3 clear;
4 close;
5 format('v',6)
6 a=5; //aceleration in kmphs
7 t1=30; //in seconds
8 vm=a*t1; //maximum speed in kmph
9 tfr=10; //time for free running in mins
10 b=5; //retardation in kmphs
11 ts=vm/b; //time for retardation in seconds
12 dta=((vm*t1)/(2*3600)); //distance travelled during
   acceleration period
13 dtfr=((vm*tfr*60)/(3600)); //distance travelled
   during retardation period
14 dtbp=dta; //distance travelled during breaking period
15 td=dta+dtfr+dtbp; //total distance between stations
16 disp(" part (a) ")
```



```

17 disp(td,"total distance between station in km")
18 T=[0;t1;(t1+(tfr*60));(t1+(t1+(tfr*60)))];//
19 V=[0;vm;vm;0];//
20 plot2d(T,V)
21 xlabel("Time in seconds ")
22 ylabel("Sppeed in Km per Hour")
23 va=(td*3600)/(t1+(tfr*60)+ts);//average speed in
    kmph
24 disp(" part (b) ")
25 disp(va,"average speed in kmph")
26 tst=5;//stop time in mins
27 vs=(td*3600)/(t1+(tfr*60)+ts+(tst*60));//sheduled
    speed in kmph
28 disp(" part (c) ")
29 disp(vs,"sheduled speed in kmph")

```

---

Scilab code Exa 7.2 plot the curve

```

1 //Example 7.2 //draw the curve
2 clc;
3 clear;
4 close;
5 a=1.7;//aceleration in kmphps
6 b=3.3;//kmphps
7 s=1400;//m
8 va=42;//kmph
9 tr=((s*10^-3)/va)*3600;//secomds
10 k=((1/(2*a))+((1/(2*b))));//
11 vm=((tr/(2*k))-sqrt(((tr^2)/(4*k^2))-((3600*s*10^-3)
    /k)));//in kmph
12 t1=vm/a;//seconds
13 t3=vm/b;//seconds
14 t2=tr-(t1+t3);//seconds
15 T=[0;(t1);(t1+t2);(t1+t2+t3)];
16 V=[0;vm;vm;0];

```

```
17 plot2d(T,V);
18 xlabel("Time in seconds ")
19 ylabel("Spped in Km per Hour")
```

---

### Scilab code Exa 7.3 speed

```
1 //Example 7.3 //maximum speed
2 clc;
3 clear;
4 close;
5 format('v',4)
6 a=2.4;//aceleration in kmphs
7 b=3.2;//retardation in kmphs
8 s=1.5;//in km
9 vs=45;//shedule speed in kmph
10 ts=(s*3600)/vs;//shedule time in seconds
11 tst=20;//stop time
12 tr=ts-tst;//actual time for run in seconds
13 k=((1/(2*a))+(1/(2*b)));//constant
14 vm=((tr/(2*k))-sqrt(((tr^2)/(4*k^2))-((3600*s)/k)));
    //in kmph
15 disp(vm,"maximum speed in kmph")
```

---

### Scilab code Exa 7.4 sceduled speed

```
1 //Example 7.4 //sheduled speed
2 clc;
3 clear;
4 close;
5 format('v',4)
6 s=1.5;//in Km
7 a=0.8;//aceleration in kmphs
8 tsr=26;//time for stop in seconds
```

```

9  rm=1.3; //ratio
10 b=3.2; //retardation in kmphs
11 k=((1/(2*a))+(1/(2*b))); //constant
12 T=1; //assume
13 va1=(3600*s)/T; //average speed
14 vm1=(va1*rm); //maximum speed
15 vm=sqrt((vm1-va1)/k); //maximum speed in kmph
16 va=vm/1.3; //actua speed in kmpj
17 ta=(3600*s)/va; //actual time in seconds
18 ts=ta+tsr; //shedule time
19 vs=(s*3600)/ts; //shedule speed in kmph
20 disp(vs,"schedule speed in kmph")

```

---

#### Scilab code Exa 7.5 acceleration

```

1 //Example 7.5: Acceleration
2 clc;
3 clear;
4 close;
5 //given data :
6 S=1; // in km
7 Vs=30; // in km/h
8 Ts=(S*3600)/Vs; // in sec
9 D=20; // duration of stop in sec
10 T=Ts-D; // in sec
11 Va=(S*3600)/T; // Average speed in km/h
12 Vm=1.25*Va; // Maximum speed in km/h
13 beta1=3; // braking retardation in km/h/sec
14 A=((Vm*T)-(S*3600))/Vm^2;
15 B=1/(2*beta1);
16 alfa=1/(2*(A-B));
17 disp(alfa,"The Acceleration , alfa (km/h/sec) = ")

```

---

### Scilab code Exa 7.6 retardation

```
1 //Example 7.6: Retardation
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',6)
7 S=4; // in km
8 Vs=45; // in km/h
9 Ts=(S*3600)/Vs; // in sec
10 D=30; // duration of stop in sec
11 T=Ts-D; // in sec
12 Vm=70; // Maximum speed in km/h
13 alfa=1.5; // in km/h/sec
14 A=((Vm*T)-(S*3600))/Vm^2;
15 B=1/(2*alfa);
16 Beta=1/(2*(A-B));
17 disp(Beta,"Retardation (km/h/sec) = ")
```

---

### Scilab code Exa 7.7 duration of acceleration coasting and braking periods

```
1 //Example 7.7: Acceleration , Coasting and Braking
  periods
2 clc;
3 clear;
4 close;
5 //given data :
6 S=1.6; // in km
7 Va=40; // in km/h
8 V1=64; // in km/h
9 alfa=2.0; //in km/p/sec
10 Beta_c=0.16; // in km/h/sec
11 Beta=3.2; // in km/h/sec
12 t1=V1/alfa; // in sec
```

```

13 disp(t1,"Duration of Acceleration ,t1(sec) = ")
14 T=(S*3600)/Va; // in sec
15 // Formula: T=(V1/alfa)+((V1-V2)/Beta_c)+(V2/Beta)
16 V2=(t1+(V1/Beta_c)-T)/((1/Beta_c)-(1/Beta));
17 t2=(V1-V2)/Beta_c;
18 disp(t2,"Duration of coasting ,t2(sec) = ")
19 t3=V2/Beta;
20 disp(t3,"Duration of braking ,t3(sec) = ")

```

---

#### Scilab code Exa 7.8 torque

```

1 //Example 7.8: Torque
2 clc;
3 clear;
4 close;
5 //given data :
6 W=200; // weight of train in tonnes
7 D=0.9; // diameter in m
8 G=(1/200)*100; //percentage gradient
9 r=50; // in N/tonne
10 gama=4; // gear ratio
11 eta=0.80; // gearing efficiency
12 We=1.10*W; // in tonne
13 Vm=48; // maximum speed in km/h
14 t1=30; // in sec
15 alfa=Vm/t1; // in km/h/sec
16 Ft=(277.8*We*alfa)+(98.1*W*G)+(W*r); // tractive
    effect required in N
17 T1=(Ft*D)/(eta*2*gama); // in N-m
18 T=round(T1/8);
19 disp(T,"Torque developed by each motor ,T(N-m) = ")

```

---

#### Scilab code Exa 7.9 time taken and current

```

1 //Example 7.9: Time taken and current
2 clc;
3 clear;
4 close;
5 //given data :
6 V=3000; // line voltage in volts
7 W=200; // weight of train in tonnes
8 D=0.9; // diameter in m
9 G=(30/1000)*100; //percentage gradient
10 r=50; // in N/tonne
11 gama=4; // gear ratio
12 Vm=50; //in km/h
13 eta=0.9; // gearing efficiency
14 We=1.10*W; // in tonne
15 T=4*6000; // in N-m
16 eta_m=85/100; // efficiency of motor
17 Ft=(eta*T*2*gama)/D;
18 A=(98.1*W*G)+(W*r);
19 B=Ft-A;
20 alfa=B/(277.8*We); // tractive effect required in N
21 t=Vm/alfa;
22 disp(t,"Time taken ,t(sec) = ")
23 Po=(Ft*Vm)/3600; // in kw
24 Pi=Po/eta_m;
25 It=(Pi*1000)/V; // in A
26 I=It/4
27 disp(I,"Current drawn per motor ,I(A) = ")

```

---

#### Scilab code Exa 7.10 time taken and current

```

1 //Example 7.10: Current and time taken
2 clc;
3 clear;
4 close;
5 //given data :

```

```

6 V=36; // speed in km/h
7 W=120; // in tonne
8 G=2; // in per cent
9 r=2*9.81; // in N/tonne
10 Ft=(98.1*W*G)+(W*r);
11 e=88/100; // efficiency of motors and gear
12 VL=1500; //line voltage in volts
13 Po=(Ft*V)/3600;
14 Pi=Po/e;
15 I=(Pi*1000)/VL;
16 bc=((98.1*(2+(0.1*2)))/(277.8*1.1)); //in kmphps
17 tt=V/bc; //in seconds
18 disp(I,"current required in amperes is")
19 disp(round(tt),"time taken to come to rest in
seconds is")

```

---

**Scilab code Exa 7.11** acceleration coasting retardation and scheduled speed

```

1 //Example 7.11.// acceleration ,coasting retardation
and scheduled speed
2 clc;
3 clear;
4 close;
5 format('v',6)
6 //given data :
7 t1=24; //in sec
8 t2=69; // in sec
9 t3=11; // in sec
10 V1=48; // in km/h
11 alfa=V1/t1;
12 disp("part (a)")
13 disp(alfa,"Acceleration (km/h/sec) = ")
14 r=58; // in N/tonne
15 G=0;
16 Beta=r/(277.8*1.1);

```

```

17 disp(" part (b)")
18 disp(Beta," Retardation (kmphs) = ")
19 V2=V1-(Beta*t2);
20 S=round(((V1*t1)/7200)+(((V1+V2)*t2)/7200)+((V2*t3)
    /7200));
21 D=20; // duration of stop in sec
22 Ts=t1+t2+t3+D;
23 Vs=round((S*3600)/Ts);
24 disp(" part (c)")
25 disp(Vs," Schedule time ,Vs(kmph) = ")
26 D1=15; //when the duration of stop in sec
27 Ts_dash=t1+t2+t3+D1;
28 Vs_dash=(S*3600)/Ts_dash;
29 disp(Vs_dash," Schedule speed ,VS_dash(kmph) = ")

```

---

#### Scilab code Exa 7.12 sceduled speed

```

1 //Example 7.12: Schedule speed
2 clc;
3 clear;
4 close;
5 //given data :
6 t1=30; //in sec
7 t2=50; // in sec
8 t3=20; // in sec
9 alpha=2; //kmphs
10 V1=alpha*(t1); // in km/h
11 r=40; // in N/tonne
12 G=1;
13 bc=((98.1+r))/(277.8*1.1); //in kmphs
14 V2=V1-(bc*t2); //km/hr
15 S=(((V1*t1)/7200)+(((V1+V2)*t2)/7200)+((V2*t3)/7200)
    );
16 D=30; // duration of stop in sec
17 Ts=t1+t2+t3+D;

```



```

18 Vs=((S*3600)/Ts);
19 disp(Vs,"Schedule time ,Vs(kmph) = ")

```

---

**Scilab code Exa 7.13** maximum power and distance travelled

```

1 //Example 7.13: maximum power and total distance
2 clc;
3 clear;
4 close;
5 format('v',5)
6 //given data :
7 w=250;//in tonnes
8 we=(1+(10/100))*w;//efective weight in tonnes
9 r=5*9.81;//in N/tonne
10 G=1;//
11 t1=30;//in sec
12 t2=70;// in sec
13 alpha=2;//kmphps
14 V1=alpha*(t1);// in km/h
15 ft=(277.8*we*alpha)+(98.1*G*w)+(w*r);//in newtons
16 po=((ft*V1)/3600);//maximum power output in kW
17 n=0.97;//efficiency
18 pi=po/n;//in kW
19 G=1;
20 bc=((98.1+r))/(277.8*1.1);//in kmphps
21 V2=V1-(bc*t2);//km/hr
22 beta1=3;//retardation
23 t3=V2/beta1;//in seconds
24 S=((V1*t1)/7200)+(((V1+V2)*t2)/7200)+((V2*t3)/7200)
    );
25 disp(round(pi),"maximum power developed by traction
    motor is (kW)")
26 disp(S,"total distance travelled by train in km is")

```

---

### Scilab code Exa 7.14 energy consumption

```
1 //Example 7.14: Energy consumption
2 clc;
3 clear;
4 close;
5 format('v',8)
6 //given data :
7 Vm=52;//max speed in kmph
8 t3=15.8;// duration of braking in sec
9 D=(1/2)*Vm*(t3/3600);
10 S=1400;// in m
11 S1=(S*10^-3)-D;
12 r=50;//in N/tonne
13 WeBY_W=1.1;
14 Ec=((0.01072*Vm^2*WeBY_W)/(S*10^-3))+(0.2778*r*(S1/(
    S*10^-3)));
15 disp(Ec,"energy consumption in Wh is")
```

---

### Scilab code Exa 7.15 specific energy consumption

```
1 //Example 7.15: specific energy consumption
2 clc;
3 clear;
4 close;
5 format('v',9)
6 //given data :
7 w=1;//in tonnes
8 we=(1+(10/100))*w;//effective weight in tonnes
9 S=1525;//in meters
10 r=52.6/1000;//in N/kg
11 alpha=0.366;//m/s^2
```

```

12 V1=12.2; // in m/s
13 t1=V1/alpha; //in seconds
14 ft=we*alpha+r; //in newtons
15 ter=((1/2)*ft*V1*t1)/3600; //in watt-hours
16 seo=ter/(w*S); // in Wh/kg-m
17 n=0.65; //efficiency
18 sec1=seo/n //in Wh/kg-m
19 disp(sec1,"specific energy onsumption in Wh/kg-m")

```

---

**Scilab code Exa 7.16** sceduled speed and specific energy consumption

```

1 //Example 7.16: Schedule speed and Specific energy
  consumption
2 clc;
3 clear;
4 close;
5 //given data :
6 t1=30; //in sec
7 t2=50; // in sec
8 t3=20; // in sec
9 alpha=2; //kmphps
10 V1=alpha*(t1); // in km/h
11 r=40; // in N/tonne
12 G=1;
13 bc=((98.1+r))/(277.8*1.1); //in kmphps
14 V2=V1-(bc*t2); //km/hr
15 S=((((V1*t1)/7200)+(((V1+V2)*t2)/7200)+((V2*t3)/7200)
    );
16 D=15; // duration of stop in sec
17 Ts=t1+t2+t3+D;
18 Vs=((S*3600)/Ts);
19 disp(Vs,"Schedule speed ,Vs(kmph) = ")
20 S1=(V1*t1)/7200; //in meters
21 r=50; //in N/tonne
22 WeBY_W=1.1;

```

```

23 G=1; //
24 Ec=((0.01072*V1^2*WeBY_W)/(S))+((0.2778*(98.1*G+r))*((
    S1)/(S)));
25 N=0.75; //
26 Sec=Ec/0.75; //
27 disp(Sec," Specific energy consumption in Wh/tonne-km
    is")

```

---

**Scilab code Exa 7.17** sceduled speed and specific energy consumption

```

1 //Example 7.17: Schedule speed and specific energy
  consumption
2 clc;
3 clear;
4 close;
5 //given data :
6 t1=30; //in sec
7 t2=50; // in sec
8 t3=20; // in sec
9 alpha=2; //kmphps
10 V1=alpha*(t1); // in km/h
11 r=40; // in N/tonne
12 G=-1;
13 bc=(((-98.1+r))/(277.8*1.1)); //in kmphps
14 V2=V1-(bc*t2); //km/hr
15 S=((((V1*t1)/7200)+(((V1+V2)*t2)/7200)+((V2*t3)/7200)
    );
16 D=15; // duration of stop in sec
17 Ts=t1+t2+t3+D;
18 Vs=((S*3600)/Ts);
19 disp(Vs," Schedule speed ,Vs(kmph) = ")
20 S1=(V1*t1)/7200; //in meters
21 r=50; //in N/tonne
22 WeBY_W=1.1;
23 Ec=((0.01072*V1^2*WeBY_W)/(S))+((0.2778*(98.1*G+r))*((

```

```

        S1)/(S));
24 N=0.75; //
25 Sec=Ec/0.75; //
26 disp(Sec," Specific energy consumption in Wh/tonne-km
        is")

```

---

**Scilab code Exa 7.18** maximum power total energy consumption and specific energy consumption

```

1 //Example 7.18.//maximum power ,total energy
  consumption and specific energy consumption
2 clc;
3 clear;
4 close;
5 format('v',6)
6 //given data :
7 W=100; //in tonne
8 We=1.1*W; // in tonne
9 S=2.5; // distance in km
10 Va=50; //Average speed in kmph
11 Dr=(3600*S)/Va;
12 alfa=1; // in km/h/sec
13 Beta=2; // in km/h/sec
14 T=180;
15 r=40; //in N/tonne
16 G=1;
17 K=(1/(2*alfa))+(1/(2*Beta));
18 Vm=round((T/(2*K))-sqrt((T/(2*K))^2-((3600*S)/K)));
  // maximum speed
19 t1=Vm/alfa; // acceleration period
20 t3=Vm/Beta; // braking period
21 t2=T-(t1+t3); // in sec
22 Ft=(277.8*We*alfa)+(98.1*W*G)+(W*r);
23 P_max=round((Ft*Vm)/3600);
24 disp(" part (a)")

```

```

25 disp(P_max,"Maximum power ,(kWh) = ")
26 e=60/100; // efficiency
27 Ft=(277.8*We*alfa)+(98.1*W*G)+(W*r);
28 Ft_dash=(98.1*W*G)+(W*r);
29 P_max=round((Ft*Vm)/3600);
30 Et=((1/2)*Ft)*(Vm/3600)*(t1/3600)+((Ft_dash*Vm)
    /3600)*(t2/3600);
31 Ec=Et/e;
32 disp(" part (b) ")
33 disp(Ec,"Total Energy Consumption ,Ec(kWh) = ")
34 Sec=(Ec*1000)/(W*S);
35 disp(" part (c) ")
36 disp(Sec," Specific Energy Consumption ,(Wh/tonne-km)
    = ")

```

---

#### Scilab code Exa 7.19 maximum power and energy taken

```

1 //Example 7.19. //maximum power and energy taken
2 clc;
3 clear;
4 close;
5 //given data :
6 format( 'v',7)
7 W=203; //in tonne
8 We=1.1*W; // in tonne
9 r=44; // N/tonne
10 G=(1/500)*100; // gradient
11 Vm=45; // maximum speed in kmph
12 t1=30; // in sec
13 alfa=Vm/t1; // in kmph
14 Ft=(277.8*We*alfa)+(98.1*W*G)+(W*r); // in N
15 Po=(Ft*Vm)/3600;
16 disp(" part (a)")
17 disp(Po,"The maximum power output ,(kW) = ")
18 e=60/100; // efficiency

```

```

19 Et=(1/2)*((Ft*Vm)/3600)*(t1/3600);
20 E=(Et/e);
21 disp(" part (b) ")
22 disp(E,"The energy taken(kWh) = ")

```

---

**Scilab code Exa 7.20** maximum power and specific energy consumption

```

1 //Example 7.20.maximum power and specific energy
  consumption
2 clc;
3 clear;
4 close;
5 format('v',7)
6 //given data :
7 W=16;//in tonne
8 We=1.1*W;// in tonne
9 Vs=45;//in kmph
10 r=40;// in N/tonne
11 S=2.8;// in km
12 Ts=(S*3600)/Vs;
13 Td=30;// in sec
14 T=Ts-Td;
15 alfa=2;//in kmphs
16 Beta=3.2;// in kmphs
17 K=(1/(2*alfa))+(1/(2*Beta));
18 Vm=round((T/(2*K))-sqrt((T/(2*K))^2-((3600*S)/K)));
  // maximum speed
19 t1=Vm/alfa;// acceleration time
20 t3=Vm/Beta;// duration of braking
21 t2=T-(t1+t3);// time f free run in sec
22 Ft=(277.8*We*alfa)+(W*r);
23 P_max=(Ft*Vm)/3600;
24 disp(" part (a)")
25 disp(P_max,"Maximum power output ,(kW) = ")
26 // answer is wrong in book

```

```

27 Va=50; //Average speed in kmph
28 Dr=(3600*S)/Va;
29 T=180;
30 G=1;
31 e=80/100; //efficiency
32 Dt=(1/2)*((Vm*t3)/3600); // distance travelled during
    braking period in km
33 S1=S-Dt; // distance travelled with power in km
34 So=((0.01072*Vm^2)/S)*(We/W))+((0.2778*r*S1)/S);
35 Sec=So/e;
36 disp(" part (b)")
37 disp(Sec," Specific energy consumption ,(Wh/tonne-km)
    = ")
38 // answer is wrong in book

```

---

**Scilab code Exa 7.21** Schedule speed specific energy consumption total energy consumption and distance

```

1 //Example 7.21: Schedule speed ,specific energy
    consumption ,total energy consumption and distance
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',6)
7 t1=30; //in sec
8 t2=40; // in sec
9 t3=30; // in sec
10 alpha=2; //kmphps
11 V1=alpha*(t1); // in km/h
12 r=40; // in N/tonne
13 G=1;
14 bc=((98.1+r))/(277.8*1.1); //in kmphps
15 V2=V1-(bc*t3); //km/hr
16 Beta=2.5; //retardation

```



```

17 t4=V2/Beta; //in seconds
18 S=((V1*t1)/7200)+((V1*t2)/3600)+(((V1+V2)*t3)/7200)
    +((V2*t4)/7200));
19 D=15; // duration of stop in sec
20 Ts=t1+t2+t3+t4+D;
21 Vs=((S*3600)/Ts);
22 disp(" part (a)")
23 disp(Vs," Schedule time ,Vs(kmph) = ")
24 disp(" part (b)")
25 S1=((V1*t1)/7200)+((V1*t2)/3600); //in km
26 WeBY_W=1.1;
27 G=1; //
28 Ec=((0.01072*V1^2*WeBY_W)/(S))+((0.2778*(98.1*G+r)*((
    S1)/(S)));
29 N=0.75; //
30 Sec=Ec/0.75; //
31 disp(Sec," Specific energy consumption in Wh/tonne-km
    is")
32 disp(" part (c)")
33 W=200; //
34 tec=(Sec*W*S); //
35 disp(tec*10^-3," total energy consumption in kWh")
36 disp(" part (d)")
37 disp(S," total distance travelled in Km is")

```

---

### Scilab code Exa 7.22 specific energy consumption

```

1 //Example 7.22: specific energy consumption
2 clc;
3 clear;
4 close;
5 //given data :
6 W=500; //
7 t1=60; //in sec
8 t2=5*60; // in sec

```

```

 9 t3=3*60; // in sec
10 alpha=2.5; //kmphps
11 V1=alpha*(t1); // in km/h
12 r=25; // in N/tonne
13 G=1;
14 bc=((98.1*(8/1000)*100)+r)/(277.8*1.1); //in kmphps
15 V2=V1-(bc*t3); //km/hr
16 Beta=3; //retardation
17 t4=V2/Beta; //in seconds
18 S=((V1*t1)/7200)+((V1*t2)/3600)+(((V1+V2)*t3)/7200)
    +((V2*t4)/7200));
19 D=15; // duration of stop in sec
20 Ts=t1+t2+t3+t4+D;
21 Vs=((S*3600)/Ts);
22 S1=((V1*t1)/7200)+((V1*t2)/3600); //in km
23 WeBY_W=1.1;
24 G=1; //
25 Ec=((0.01072*V1^2*WeBY_W)/(S))
    +(0.2778*((98.1*(8/1000)*100)+r)*((S1)/(S)));
26 N=0.80; //
27 Sec=Ec/N; //
28 disp(Sec," Specific energy consumption in Wh/tonne-km
    is")

```

---

**Scilab code Exa 7.23** weight and number of axles

```

1 //Example 7.23: weight of the locomotive abd number
  of axles
2 clc;
3 clear;
4 close;
5 //given data :
6 W1=1; //
7 W1=400; //
8 G=2; //in percentage

```

```

9 mu=0.2; //
10 alpha=1; //
11 r=40; //
12 x=(277.8*1.1*alpha+98.1*G+r)/(9.81*1000); //
13 wlo=(x*W1)/(mu-x); //in tonnes
14 al=22; //allowable load in tonnes
15 na=wlo/al; //
16 disp(wlo,"weight of the locomotive in tonnes")
17 disp(round(na),"number of axles required")

```

---

**Scilab code Exa 7.24** weight and number of axles

```

1 //Example 7.24: weight of the locomotive abd number
  of axles
2 clc;
3 clear;
4 close;
5 //given data :
6 W=12*30; //tonnes
7 we=1.04*360; //tonnes
8 r=5*9.81; //
9 G=1; //in percentage
10 mu=0.2; //
11 alpha=0.8; //
12 x=13.882; //
13 y=0.041; //
14 wlo=(x)/(mu-y); //in tonnes
15 al=20; //allowable load in tonnes
16 na=wlo/al; //
17 disp(wlo,"weight of the locomotive in tonnes")
18 disp(ceil(na),"number of axles required")

```

---

**Scilab code Exa 7.25** trailing weight and maximum gradient

```

1 //Example 7.25.//trailing weight and maximum
  gradiant
2 clc;
3 clear;
4 close;
5 format('v',6)
6 //given data :
7 w1=100; //tonnes
8 w=w1+500; //tonnes
9 we=1.1*w; //effective weight
10 alpha=1; //
11 G=1; //
12 r=45; //
13 ft=((277.8*we*alpha)+(98.1*w*G)+(w*r)); //in newtons
14 ad=0.7; //adehsive percent
15 mu=(ft)/(100*10^3*9.81*ad); //
16 w2=130; //tonnes
17 ad2=w2*G; //
18 tadw=w1*ad+ad2; //tonnes
19 tted=mu*tadw*9.81*1000; //newtones
20 W=tted/(277.8*1.1*alpha+98.1*alpha+r); //in tonnes
21 trlw=W-(ad2+w1); //
22 disp("part (a)")
23 disp(round(trlw),"trailig weight in tonnes is")
24 w2=w1+500+ad2; //
25 G1=((tted/w2)-(277.8*1.1+r))*(1/98.1); //
26 disp("part (b)")
27 disp(G1,"maximum gradiant in percentage is")

```

---

#### Scilab code Exa 7.26 acceleration

```

1 //Example 7.26; acceleration
2 clc;
3 clear;
4 close;

```

```

5 //given data :
6 w1=100; //tonnes
7 w=w1+500; //tonnes
8 we=1.1*w; //effective weight
9 alpha=1; //
10 G=1; //
11 r=45; //
12 ft=((277.8*we*alpha)+(98.1*w*G)+(w*r)); //in newtons
13 ad=0.7; //adehsive percent
14 mu=(ft)/(100*10^3*9.81*ad); //
15 w2=130; //tonnes
16 ad2=w2*G; //
17 tadw=w1*ad+ad2; //tonnes
18 tted=mu*tadw*9.81*1000; //newtones
19 W=tted/(277.8*1.1*alpha+98.1*alpha+r); //in tonnes
20 trlw=W-(ad2+w1); //
21 w2=w1+500+ad2; //
22 acc=((tted/w2)-(98.1+r))*(1/(277.8*1.1)); //in kmphps
23 disp(acc,"acceleration in kmphps is")

```

---

### Scilab code Exa 7.27 torque and weight

```

1 //Example 7.27: Torque and minimum weight
2 clc;
3 clear;
4 close;
5 //given data :
6 N=4; // number of motor
7 W=250; //in tonne
8 D=.95; // diameter in m
9 G=1; // percentage gradient
10 r=40; // in N/tonne
11 eta=95/100; // gear efficiency
12 gama=3; // gear ratio
13 We=1.1*W;

```

```
14 Vm=40; // kmph
15 t1=20; // in seconds
16 alfa=Vm/t1;
17 Ft=((277.8*We*alfa)+(98.1*W*G)+(W*r));
18 T=(Ft*D)/(eta*2*gama);
19 Td=round(T/N);
20 disp(Td,"Torque developed by each motor,Td(Nm) = ")
21 mu=0.25; // adhesive coefficient
22 WL=(Ft/(9.81*1000))/mu;
23 Dw=round(WL/.75);
24 disp(Dw,"Dead weight of locomotive ,(tonnes) = ")
```

---

# Chapter 8

## Electric Traction Motors

Scilab code Exa 8.1 speed armature current characteristic

```
1 //Example 8.1: Motor speed
2 clc;
3 clear;
4 close;
5 v=230; //in volts
6 rm=0.3; //in ohms
7 Ia=[5;10;15;20;25;30;35;40]; //in amperes
8 T=[20;50;100;155;215;290;360;430]; //
9 for i=1:8
10     eb(i)= v-(Ia(i))*rm; //
11     N(i)=(9.55*eb(i)*Ia(i))/(T(i)); //
12     disp("speed in rpm is for current "+string(Ia(i))
13         )+" amperes "+string(round(N(i)))+ " RPM")
13 end
14 plot2d(Ia,N)
15 xlabel("ARMATURE CURRENT ,Ia IN AMPS")
16 ylabel("SPEED ,N IN RPM")
17 xtitle("Spped-Armature current characteristic")
```

---

### Scilab code Exa 8.2 speed torque curve

```
1 //Example 8.2: SPEED-TORQUE GRAPH
2 clc;
3 clear;
4 close;
5 v=600; //in volts
6 rm=0.8; //in ohms
7 N1=600; //
8 Ia=[20;40;60;80]; //in amperes
9 EMF=[215;381;485;550]
10 for i=1:4
11     eb(i)= v-(Ia(i))*rm; //
12     N(i)=(N1/EMF(i))*eb(i); //
13     T(i)=(9.55*eb(i)*Ia(i))/(N(i)); //
14     disp("speed in rpm is for current "+string(Ia(i))
15         +" amperes "+string(round(N(i)))+ " RPM and
16         Torque in N-m is "+string(T(i))+")")
17 end
18 plot2d(T,N)
19 xlabel("TORQUE ,T IN Nm")
20 ylabel("SPEED ,N IN RPM")
21 xtitle("Speed-torque curve")
```

---

### Scilab code Exa 8.3 motor speed and current

```
1 //Example 8.3: Motor speed and current drawn
2 clc;
3 clear;
4 close;
5 //given data :
6 N1=640; // in rpm
7 I1=15; // in A
8 I2=sqrt((2)*sqrt(2)*I1^2);
9 N2=round((2*I1*N1)/I2);
```



```
10 disp(I2," Current drawn , I2 (A) = ")
11 disp(N2," Motor speed ,N2(rpm) = ")
```

---

#### Scilab code Exa 8.4 speed and voltage

```
1 //Example 8.4: speed and voltage
2 clc;
3 clear;
4 close;
5 n1=700; //rpm
6 n2=750; //rpm
7 rm=0.3; //in ohms
8 v=500; //in volts
9 ib=50; //amperes
10 eb1=v-(ib*rm); //in volts
11 eb2=eb1; //
12 N=((v-(2*(ib*rm)))/((eb1/n1)+(eb2/n2))); //
13 pdv1=((eb1/n1)*N)+ib*rm; //in volts
14 pdv2=((eb1/n2)*N)+ib*rm; //in volts
15 disp(round(N)," speed in rpm is")
16 disp(round(pdv1),"PD across machine 1 in volts is")
17 disp(round(pdv2),"PD across machine 2 in volts is")
```

---

#### Scilab code Exa 8.5 current

```
1 //Example 8.5: Current drawn
2 clc;
3 clear;
4 close;
5 format('v',5)
6 //given data :
7 V=500; // in volts
8 Vm=40; // in kmph
```

```

 9 Ft=1800; // in N
10 Rm=0.4; // in ohm
11 Lm=3200; // losses per motor in watt
12 Mo=(Ft*Vm*1000)/3600;
13 Cl=3200; // constant losses in watt
14 // formul: Mi=Po+Cl+C_losses
15 // C_losses=I^2*Rm
16 // Mi=V*I
17 // I1=(V+sqrt(V^2-(4*Rm*(Mo+Cl))))/(2*Rm); leaving as
    gives a very high value
18 I1=(V-sqrt(V^2-4*Rm*(Mo+Cl)))/(2*Rm);
19 disp(I1,"Current drawn by each motor,(A) =");
20 It=I1*2;
21 disp(It,"Total current drawn,(A) = ")

```

---

### Scilab code Exa 8.6 power delivered

```

1 //Example 8.6.//power delivered
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',6)
7 Ft=35300; // in N
8 V=48; // in kmph
9 Po=((Ft*V*1000)/3600)*10^-3;
10 Ft1=55180; //in N
11 Pd=Po*sqrt(Ft1/Ft);
12 disp("part (a)")
13 disp(Pd,"power delivered(kW) = ")
14 Pd1=Po*(Ft1/Ft);
15 disp("part (b)")
16 disp(Pd1,"power delivered(kW) = ")

```

---

### Scilab code Exa 8.7 new characteristics

```
1 //Example 8.7: speed and tractive effort
2 clc;
3 clear;
4 close;
5 Ia=[60;120;180;240;300;360]; // in amperes
6 sp1=[80;50;45;42;38;35]; //in kmph
7 tf1=[1.7;5;10;14;16;20]; //innewtons
8 d1=0.85; //in meters
9 d2=0.9; //in meters
10 y1=71/21; //
11 y2=74/19; //
12 for i=1:6
13     V(i)=((d2/d1)*(y1/y2))*sp1(i); //in kmph
14     tf2(i)=((d1/d2)*(y2/y1))*(tf1(i)); //in newtons
15     disp("for armature current "+string(Ia(i))+
           amperes , speed is "+string(V(i))+ " kmph and
           tractive effor in thousand newtons is "+
           string(tf2(i))+ ")")
16 end
```

---

### Scilab code Exa 8.8 motor speed

```
1 //Example 8.8: speed
2 clc;
3 clear;
4 close;
5 n1=500; //in rpm
6 d1=90; //in cm
7 d2=86; //in cm
8 v=600; //in volts
```

```

9 vd=0.1; //drop
10 eb1=v-(vd*v); //in volts
11 A=[90 -86;90 90]; //
12 B=[240;54000]; //
13 X=A\B; //
14 V1=X(1,1); //in volts
15 V2=X(2,1); //in volts
16 N1=n1*(V1-(vd*v))/(eb1); //
17 N2=N1*(d1/d2); //
18 disp(round(N1), " speed in rpm is")
19 disp(round(N2), "speed in rpm is")
20 //N2 is calculated wrong in the book

```

---

#### Scilab code Exa 8.9 power input and tractive efforts

```

1 //Example 8.9;power input and tractive efforts
2 clc;
3 clear;
4 close;
5 ia=350; //A
6 ib=305; //A
7 v=600; //V
8 pa=(v*ia)/1000; //kW
9 pb=(v*ib)/1000; //kW
10 disp("(i) When motors are connected in parallel and
      train speed is 40kmph")
11 disp(pa, "power input to motor A is ,(kW)=")
12 disp(pb, "power input to motor B is ,(kW)=")
13 fta=1625; //kg
14 ftb=1480; //kg
15 disp(fta, "tractive effor of motor A is ,(kg)=")
16 disp(ftb, "tractive effor of motor B is ,(kg)=")
17 disp("(ii) When motors are connected in series and
      current is 400A")
18 rm=0.08; //ohm

```

```

19 i=400; //A
20 eba=v-(i*rm); //V
21 abb=eba; //V
22 va=38.5; //V
23 vb=36.7; //V
24 vx=((v-2*(i*rm))*((va*vb)/(va+vb)))/eba; //
25 Va=((eba/va)*vx)+(i*rm); //V
26 Vb=((eba/vb)*vx)+(i*rm); //V
27 pa1=(Va*i)/1000; //kW
28 pb1=(Vb*i)/1000; //kW
29 disp(pa1,"power input to motor A is ,(kW)=")
30 disp(pb1,"power input to motor B is ,(kW)=")
31 fta1=1960; //kg
32 ftb1=2060; //kg
33 disp(fta1,"tractive effor of motor A is ,(kg)=")
34 disp(ftb1,"tractive effor of motor B is ,(kg)=")

```

---

**Scilab code Exa 8.10** linear synchronous and vehicle speed

```

1 //Example 8.10;linear synchronous velocity
2 clc;
3 clear;
4 close;
5 f=50; //hz
6 t=0.5; //in meter
7 s=0.25; //
8 vs=2*f*t*(3600/1000); //kmph
9 vc=vs*(1-s); //kmph
10 disp(vs,"linear synchronous velocity in kmph is")
11 disp(vc,"vehicle speed in kmph is")

```

---

# Chapter 9

## Control of Traction Motors

Scilab code Exa 9.1 energy lost and total energy

```
1 //Example 9.1.//energy lost and total energy
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',7)
7 V=600; // in volts
8 I=350; //in A
9 Ts=20; // in sec
10 R=0.15; // in ohm
11 E_bse=(V/2)-(I*R);
12 E_bp=V-(I*R);
13 Tse=(E_bse/E_bp)*Ts;
14 Tp=Ts-Tse;
15 Vd=V-(2*I*R);
16 Ed1=(Vd/2)*I*(Tse/3600);
17 Ed2=((V/2)/2)*2*I*(Tp/3600);
18 E1=(Ed1+Ed2)*10^-3;
19 disp(" part (a)")
20 disp(E1,"Energy lost in starting rheostat ,E1(kWh) = ")
    )
```

```

21 El_1=(2*(I^2)*R*Ts)/(3600*1000);
22 disp(" part (b)")
23 disp(El_1,"Energy lost in motors ,El(kWh) = ")
24 //answer is wrong in part b in the textbook
25 Et=((V*I*Tse)+(2*V*I*Tp))/(3600*1000);
26 disp(" part (c)")
27 disp(Et,"Total Energy ,Et(kWh) = ")

```

---

### Scilab code Exa 9.2 rheostatic losses and train speed

```

1 //Example 9.2.rheostatic losses and train speed
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',7)
7 V=600;// in volts
8 I=300;//in A
9 Ts=15;// in sec
10 R=0.1;// in ohm
11 E_bse=(V/2)-(I*R);
12 E_bp=V-(I*R);
13 Tse=(E_bse/E_bp)*Ts;
14 Tp=Ts-Tse;
15 Vd=V-(2*I*R);
16 Ed1=(round((Vd/2)*I*(Tse/3600))*10^-3);//
17 disp(" part (i)")
18 disp(Ed1,"rheostatic in series ,Ed1(kWh) = ")
19 Ed2=((V/2)/2)*2*I*(Tp/3600)*10^-3;
20 disp(Ed2,"rheostatic in parallel ,Ed2(kWh) = ")
21 Vm=29;// in kmph
22 alfa=Vm/Ts;
23 S=alfa*Tse;
24 disp(" part (ii)")
25 disp(S,"Speed at the end of series period ,S(km/h) =

```

)

---

### Scilab code Exa 9.3 efficiency and speed

```
1 //Example 9.3. efficiency and speed
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',5)
7 V=600; // in volts
8 I=200; //in A
9 Ts=20; // in sec
10 R=0.1; // in ohm
11 E_bse=(V/2)-(I*R);
12 E_bp=V-(I*R);
13 Tse=(E_bse/E_bp)*Ts;
14 Tp=Ts-Tse;
15 Vd=V-(2*I*R);
16 Mi=((V*I*Tse)/(2*3600))+((V*I*Tp)/3600);
17 Er=((Vd/4)*I*(Tse/3600))+(((V/2)/2)*I*(Tp/3600));
18 El=(I^2*R*Ts)/(3600);
19 Mo=Mi-Er-El;
20 eta=(Mo/Mi)*100;
21 disp("part (a)")
22 disp(eta," Starting efficiency ,(%) = ")
23 Vm=80; // in kmph
24 alfa=Vm/Ts;
25 S=alfa*Tse;
26 disp("part (b)")
27 disp(S," speed ,S(kmph) = ")
```

---

### Scilab code Exa 9.4 time duration speed and rheostatic losses



```

1 //Example 9.4 time duration ,speed and rheostatic
  losses
2 clc
3 clear;
4 close;
5 //given data :
6 format('v',6)
7 W=150; // in tonne
8 We=1.1*W; // in tonnes
9 Vm=30; //kmph
10 V=600; // in volts
11 r=10; // N/tonne
12 I=300; //in A
13 R=0.1; // in ohm
14 Ft=4*15000; // in N
15 G=1; //gradient in %
16 alfa=(Ft-(W*r)-(98.1*W*G))/(277.8*We);
17 Ts=Vm/alfa;
18 E_bse=(V/2)-(I*R);
19 E_bp=V-(I*R);
20 Tse=(E_bse/E_bp)*Ts;
21 disp(" part (a)")
22 disp(Ts," Duration of starting period ,Ts(seconds) = "
  )
23 disp(Tse," Duration for Series running ,Tse(seconds) =
  ")
24 sptr=alfa*Tse; //in kmph
25 disp(" part (b)")
26 disp(sptr," speed of train at transition in kmph is")
27 sptr=alfa*Tse; //in kmph
28 rls=((V-(2*I*R))/2)*(2*I)*(Tse/3600); //watts hours
29 rlp=((V/2)/2)*(4*I)*((Ts-Tse)/3600); //watts hours
30 t1=rls+rlp; //
31 disp(" part (c)")
32 disp(rls," rheostat losses during series operation in
  W-hours")
33 disp(rlp," rheostat losses during parallel operation
  in W-hours")

```

34 `disp(t1,"total losses in W-hours is")`

---

#### Scilab code Exa 9.5 diverter resistance

```
1 //Example 9.5:diverter resistance
2 clc;
3 clear;
4 close;
5 format('v',6)
6 nf=1; //
7 n2=1.25*nf; //
8 of=1; //
9 of2=nf/n2; //
10 isef=1; //
11 ise2=0.66667; //
12 ia2=(1/ise2); //
13 idiv=ia2-ise2; //
14 rdiv=ise2/idiv; //
15 disp(rdiv*100,"diverter resistance required as
    percentage of the field resistance is")
16 //answer is wrong in the textbook
```

---

#### Scilab code Exa 9.6 speed and drawbar pull

```
1 //Example 9.6:draw chracterstics
2 clc;
3 clear;
4 close;
5 format('v',6)
6 Ia=[60;80;100;120;160;180]; // in amperes
7 sp1=[47.4;40.3;35.8;33.9;29.8;28.5]; //in kmph
8 dpk=[440;700;970;1245;1800;2360]; //in kg
9 sp2=[58.1;50;45;40.3;35;32]; //
```

```
10 for i=1:6
11     dpk1(i)= ((dpk(i))*(sp1(i)))/(sp2(i));//
12     disp("for current "+string(Ia(i))+ " amperes ,
           speed in kmph is "+string(sp2(i))+ " and
           drawbar pull in kg is "+string(dpk1(i))+ " ")
13 end
```

---

# Chapter 10

## Braking Mechanical Consideration and Control Equipment

Scilab code Exa 10.1 braking torque

```
1 //Example 10.1:braking torque
2 clc;
3 clear;
4 close;
5 I=[50;100;150;200;250]; //
6 sp=[73.6;48;41.1;37.3;35.2];
7 T=[150;525;930;1335;1750];
8 v=600; //in volts
9 rm=0.6; //
10 eb=v-(I(2)*rm); //in volts
11 rh=3; //in ohms
12 tr=rh+rm; //in ohms
13 i=eb/tr; //in amperes
14 tr=T(3); //
15 disp(tr,"braking torque is (N-m)")
```

---

### Scilab code Exa 10.2 resistance

```
1 //Example 10.2: reistance
2 clc;
3 clear;
4 close;
5 I=[20;40;60;80];//
6 emf=[215;381;485;550];//in volts
7 emf2=[202;357;455;516];//
8 lt=40*9.81;// in N-m
9 N=600;//rpm
10 il=lt*(2*%pi*(N/60));//in W
11 ia=56;//in amperes from curve
12 va=440;//in volts from graph
13 tr=va/ia;// in ohms
14 tm=0.8;//in ohms
15 er=tr-tm;//in ohms
16 disp(er,"external resistance to be connected across
    the motor during break is in ohm")
```

---

### Scilab code Exa 10.3 electrical energy and average power

```
1 //Example 10.3: Electrical energy and average power
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',6)
7 W=400;//in tonne
8 We=1.1*W;// in tonne
9 S=2;// distance in km
10 G=2;// gradient in %
```

```

11 eta=75/100; // efficiency
12 D=2; // distance in km
13 V1=40; // in km
14 V2=20; // in km
15 r=40; //N/tonne
16 Ea=(0.01072*We*(V1^2-V2^2))*10^-3; // in kWh
17 Ft=(W*r) - (98.1*W*G);
18 M=(-Ft*S*1000)/(1000*3600);
19 Et=Ea+M; // total energy available
20 Ee=eta*Et;
21 disp(Ee,"Electrical energy ,Ee(kWh) = ")
22 As=(V1+V2)/2; // average speed
23 At=D/As; // Average time taken
24 P=round(Ee/At);
25 disp(P,"Average power ,P(kW) = ")

```

---

#### Scilab code Exa 10.4 energy returned

```

1 //Example 10.4: Energy returned to the line
2 clc;
3 clear;
4 close;
5 //given data :
6 W=2340; //in tonne
7 We=1.1*W; // in tonne
8 G=100/80; // gradient in %
9 eta=70/100; // efficiency
10 V1=60; // in km
11 V2=36; // in km
12 r=5*9.81; //N/tonne
13 t=5*60; // in sec
14 Ea=(0.01072*We*(V1^2-V2^2))*10^-3; // in kWh
15 Ft=(W*r) - (98.1*W*G); //tractive effort in N
16 D=((V1+V2)/2)*(1000/3600)*t; // distance moved in m
17 M=(-Ft*D)/(1000*3600);

```

```
18 Et=Ea+M;
19 El=eta*Et;
20 disp(El,"Energy returned to the line ,El(kWh) = ")
```

---

#### Scilab code Exa 10.5 power

```
1 //Example 10.5: Energy returned to the line
2 clc;
3 clear;
4 close;
5 //given data :
6 W=500;//in tonne
7 G=(20*100)/1000;// gradient in %
8 eta=75/100;// efficiency
9 V=40;// in kmph
10 r=40;//N/tonne
11 Ft=(W*r) -(98.1*W*G);//tractive effort in N
12 P=(-Ft*V)/3600;// Power available in kW
13 Pf=round(P*eta);
14 disp(Pf,"power fed into the line ,Pf(kW) = ")
```

---

#### Scilab code Exa 10.6 power

```
1 //Example 10.6: Power generated
2 clc;
3 clear;
4 close;
5 //given data :
6 OD=640;// voltage represent by phasor OD
7 R=0.5;// reactor in ohm
8 Ia=OD/R;
9 V=400;// in volts
10 alfa=38.66;//Phase angle in degree
```

```
11 P=(V*Ia*cosd(alfa))*10^-3;  
12 disp(P,"Power generated ,P(kW) = ")
```

---



# Chapter 11

## Power supply for electric traction

Scilab code Exa 11.1 total length

```
1 //Example 11.1: Total Length
2 clc;
3 clear;
4 close;
5 //given data :
6 l=20; // in m
7 w=0.5; // weight per meter in kg
8 T=500; // Tension applied in kg
9 del=(w*l^2)/(2*T);
10 two_S=2*(1+(2/3)*(del^2/l));
11 disp(two_S,"Total Length(m) = ")
```

---

Scilab code Exa 11.2 sag

```
1 //Example 11.2: Sag
2 clc;
```

```

3 clear;
4 close;
5 //given data :
6 format('v',5)
7 l=30; // in meter
8 w=0.72; // weight per meter in kg
9 E=640; // in kg/cm^2
10 d=1; // diameter in cm
11 T=E*(%pi/4)*d^2;
12 del=((w*l^2)/(2*T))*100;
13 disp(del," sag (cm) = ")

```

---

### Scilab code Exa 11.3 sag

```

1 //Example 11.3: Sag
2 clc;
3 clear;
4 close;
5 //given data :
6 l=30; // in meter
7 w1=0.9; // average weight of catenary wire in kg/m
8 w2=1.2 //average weight of trolley wire in kg/m
9 w3=(20/100)*w2 //average weight of dropper and
   fittings in kg/m
10 w=w1+w2+w3;
11 T=1000; // in kg
12 del=((w*l^2)/(2*T));
13 disp(del," sag (m) = ")

```

---

### Scilab code Exa 11.4 current

```

1 //Example 11.4: Current
2 clc;

```

```

3 clear;
4 close;
5 //given data :
6 I=300; // in A
7 R=0.08; // in ohm
8 Vd=6; // voltage drop in volts
9 I_dash=((R*(I/2))-Vd)/R;
10 disp(I_dash, "Current(A) = ")

```

---

#### Scilab code Exa 11.5 potential

```

1 //Example 11.5: Current
2 clc;
3 clear;
4 close;
5 //given data :
6 a=7; //far end voltage in volts
7 i=125; // in A
8 r=0.02; // in ohm
9 l=3; // in km
10 p=(i*r*l^2)/2;
11 I=((p-a)/(r*l)); //
12 disp(p, "potential of the track at the far end of the
    section in volts is")
13 disp(I, "Current carried by -ve feeder, I(A) = ")

```

---

#### Scilab code Exa 11.6 current

```

1 //Example 11.6: Current
2 clc;
3 clear;
4 close;
5 //given data :

```

```

6  format('v',8)
7  ix=200; //amperes
8  r=0.02; //in ohms
9  x=poly(0,"x");
10 p=-19+12*x+0*x^2; //
11 y=roots(p); //km
12 ipx=ix*(3-y); //in amperes
13 inx=2*ix; //in amperes
14 it=ipx+inx; //in amperes
15 disp(it,"current through negative booster in amperes
        is")

```

---

#### Scilab code Exa 11.7 voltage and kW

```

1  //Example 11.7: potential drop and capacity if
    booster
2  clc;
3  clear;
4  close;
5  //given data :
6  format('v',8)
7  ix=250; //amperes
8  vb=2; //in volts
9  r=0.02; //in ohms
10 x=poly(0,"x");
11 p=-27.6+16*x+0*x^2; //
12 y=roots(p); //km
13 pc=vb+(ix*r*(1.6)^2)/2; //in volts
14 pd=((ix*r*(y^2))/2); //in volts
15 tcurr= (1.6*ix)+((ix*(3.2-y))); //in amperes
16 vnf=r*tcurr; //in volts
17 bnb=vnf-vb; //in volts
18 cb=((bnb*tcurr)/1000); //in kw
19 disp(pc,"maximum potential drop on any two points on
        the rails in volts is")

```

```
20 disp(cb,"capacity of booster in kW is")
```

---

#### Scilab code Exa 11.8 rating of the booster

```
1 //Example 11.8: rating of booster
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',8)
7 i=200; // A/km
8 r=0.01; //in ohms/km
9 x=poly(0,"x")
10 p=-20+8*x+0*x^2; //
11 y=roots(p); //km
12 i1=400; //in amperes
13 i2=(4-y)*i //in amperes
14 tc=i1+i2; //in amperes
15 vcn=r*tc; //in volts
16 nb=vcn-4; //in volts
17 rb=(tc*10)/1000; //
18 disp(rb,"rating of the booster in kW is")
```

---

#### Scilab code Exa 11.9 voltage

```
1 //Example 11.9 //voltage
2 clc;
3 clear;
4 close;
5 format('v',5)
6 vw=60; //in volts
7 vt=12; //in volts
8 tv=vw+vt; //in volts
```

```
9 vs=600; //in volts
10 va=vs-tv; //in volts
11 vr=578; //volts
12 vn=10; //in volts
13 vtn=tv-vn; //in volts
14 vad=vs-vr; //
15 vp=vtn-vad; //in volts
16 disp(" part (a)")
17 disp(va," voltage available to trolley when it is at
    the far end without using boosters in volts is")
18 disp(" part (b)")
19 disp(" positive booster should provide boost of "+
    string(vp)+" volts")
```

---