CHAPTER – 5.

5.1 System Flow Chart

5.2 Program Flow Chart

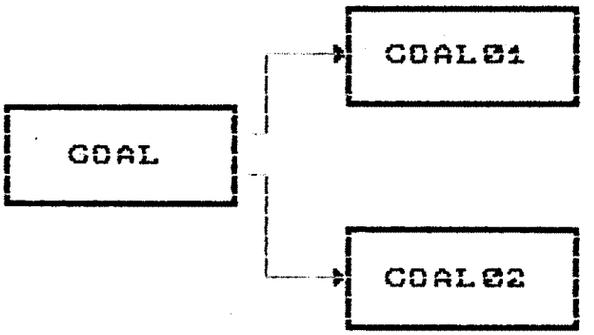
5.3 Listing of Computer Program

5.4 Computer Output

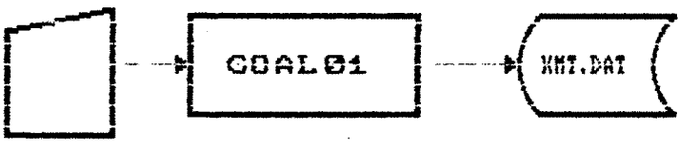
5.5 Analysis

SYSTEM FLOW CHART

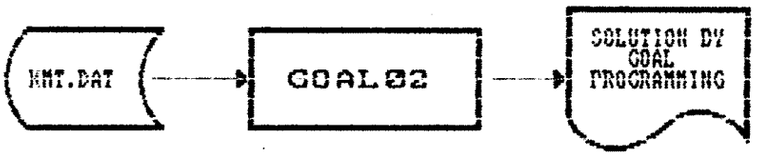
MENU PROGRAM



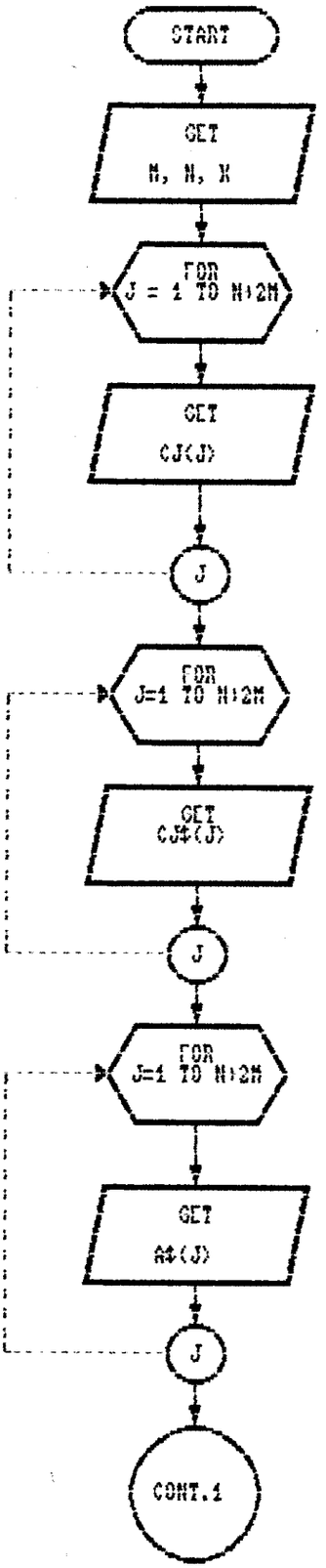
1.

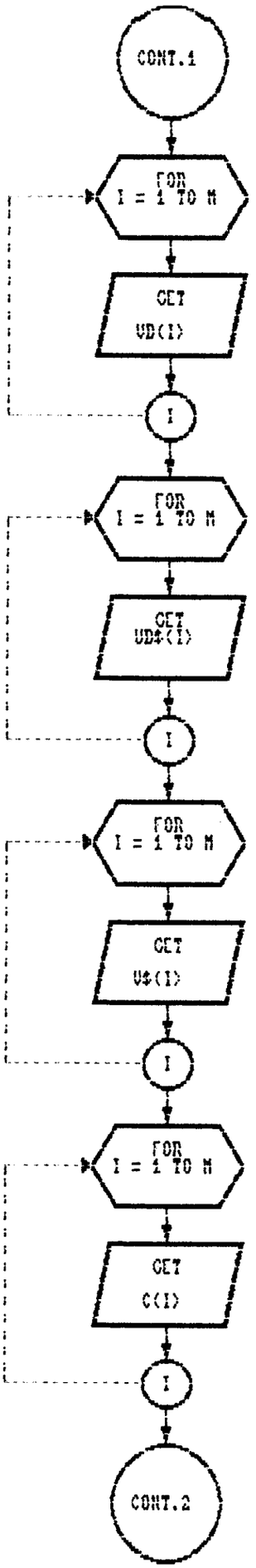


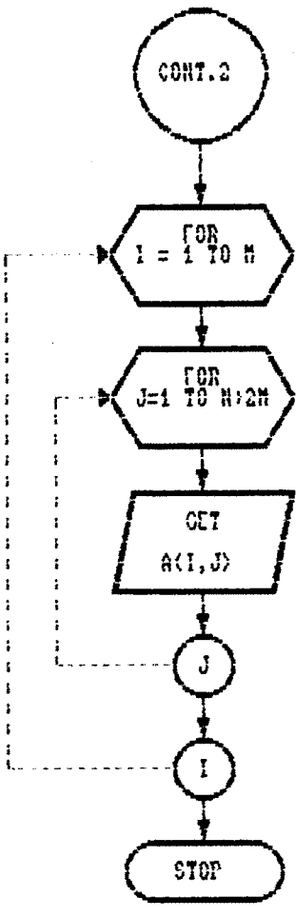
2.



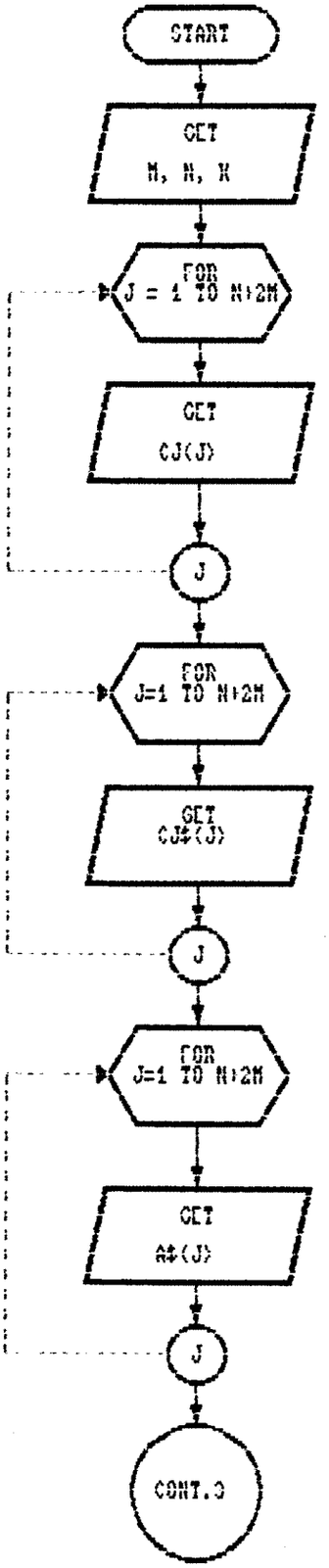
PROGRAM FLOW CHART
COAL01.BAS
FOR CREATING DATA FILE

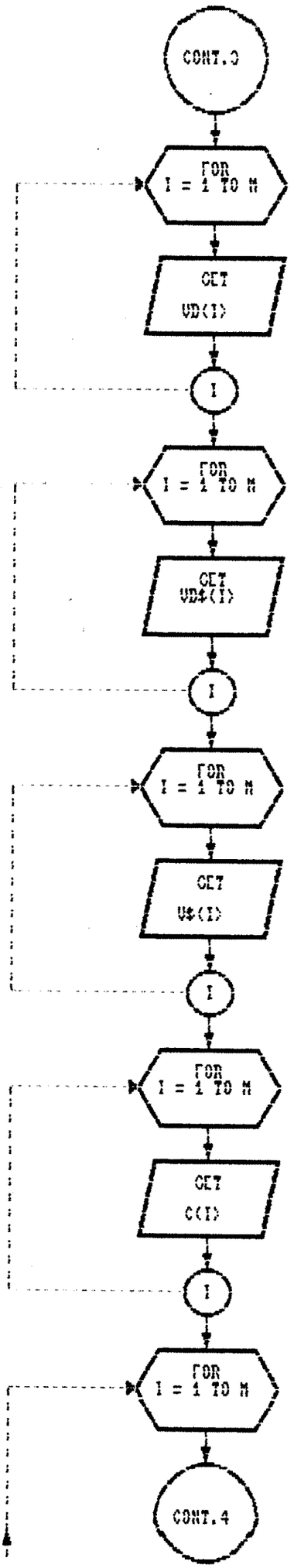


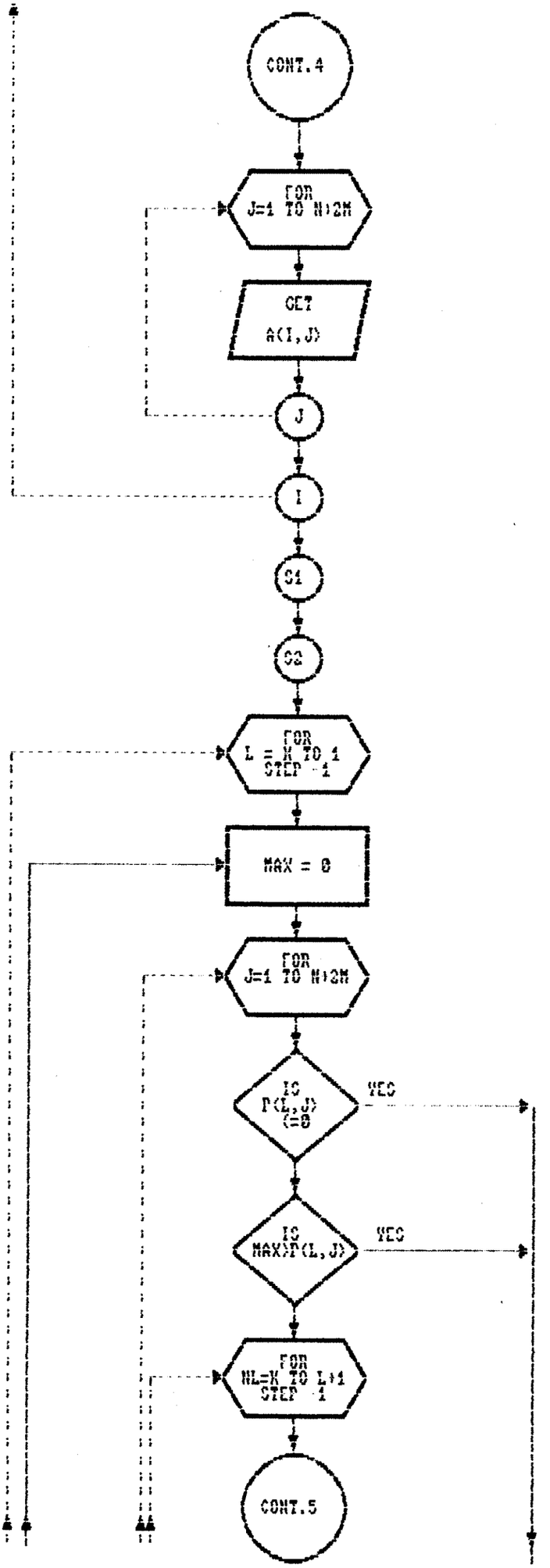

CONT.1
FOR
I = 1 TO M
GET
UD(I)
I
FOR
I = 1 TO M
GET
UD$(I)
I
FOR
I = 1 TO M
GET
U$(I)
I
FOR
I = 1 TO M
GET
C(I)
I
CONT.2

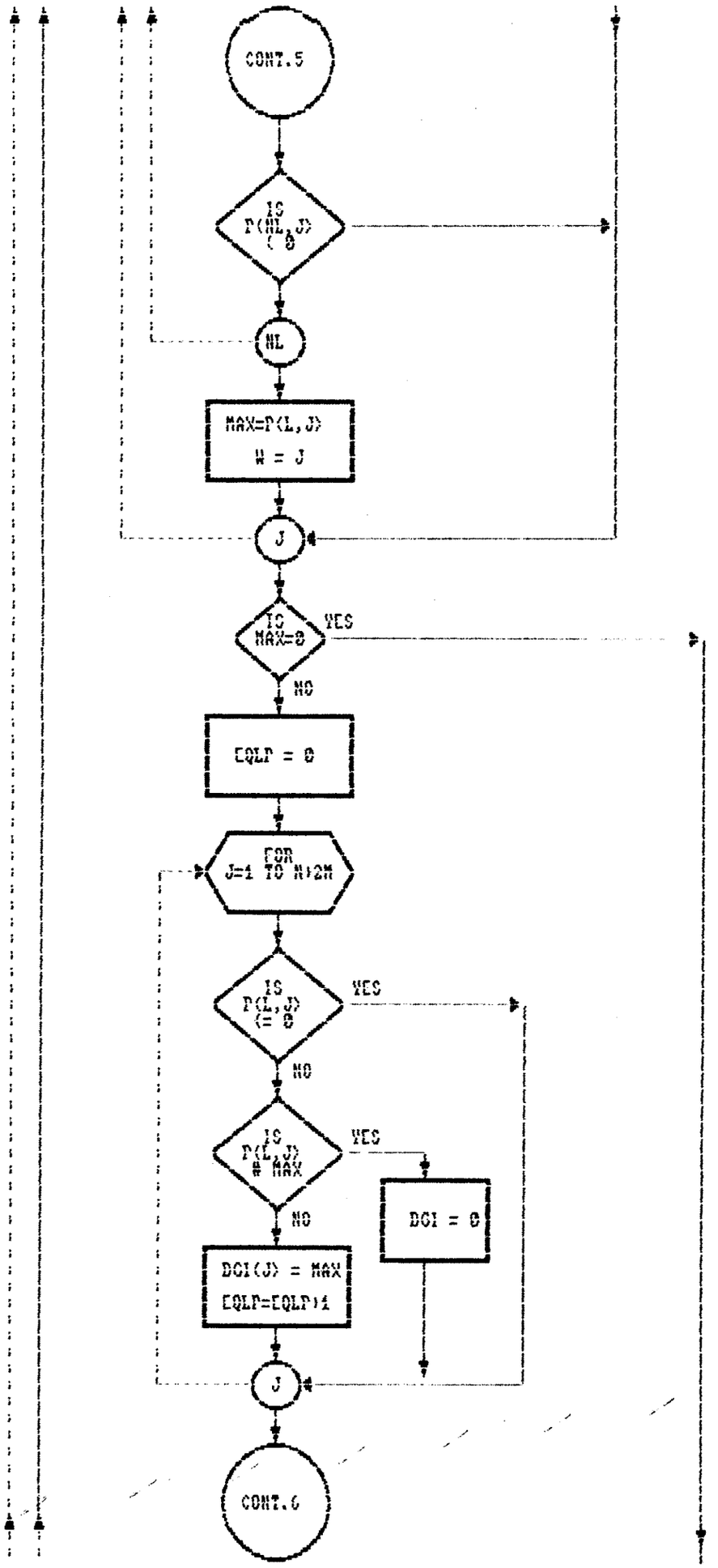

CONT.2
FOR
I = 1 TO M
FOR
J=1 TO N*2M
GET
A(I,J)
J
I
STOP

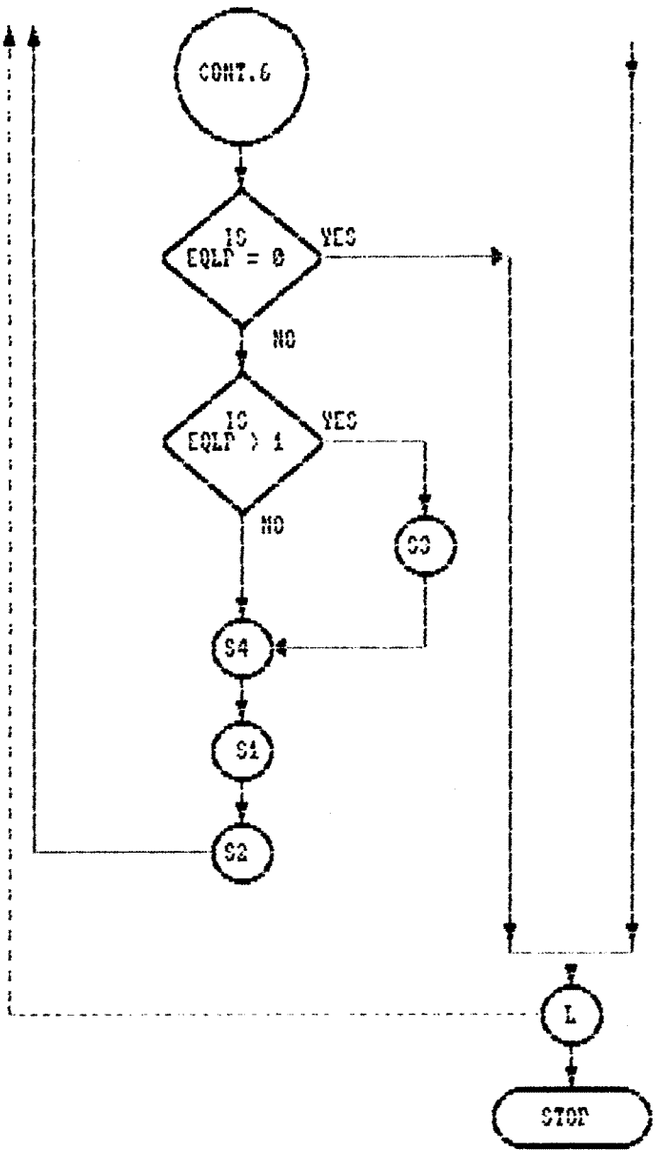
COAL02.DAS
FOR GENETARING THE SOLUTION OF THE DATA
AVAILABLE BY COAL PROGRAMMING

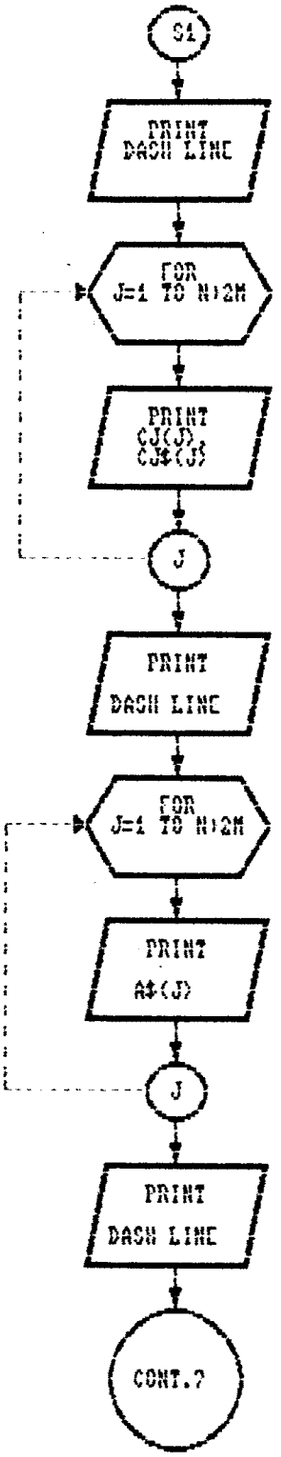


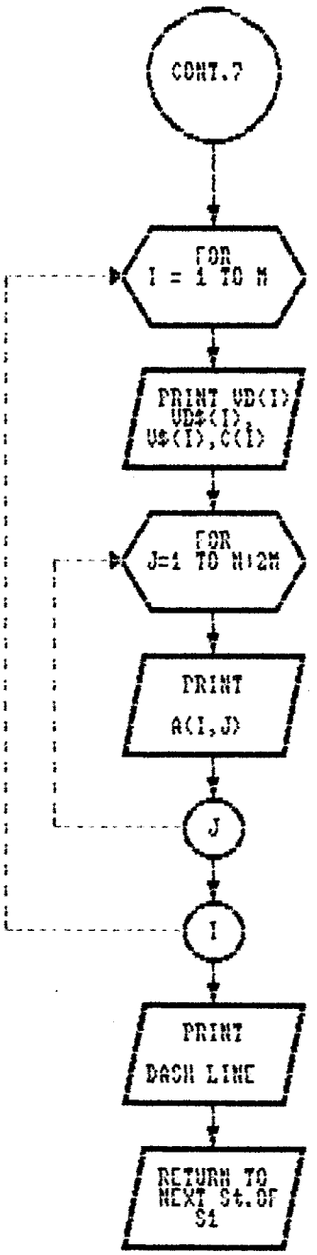

CONT.3
FOR
I = 1 TO M
GET
UD(I)
I
FOR
I = 1 TO M
GET
UD$(I)
I
FOR
I = 1 TO M
GET
U$(I)
I
FOR
I = 1 TO M
GET
C(I)
I
FOR
I = 1 TO M
CONT.4

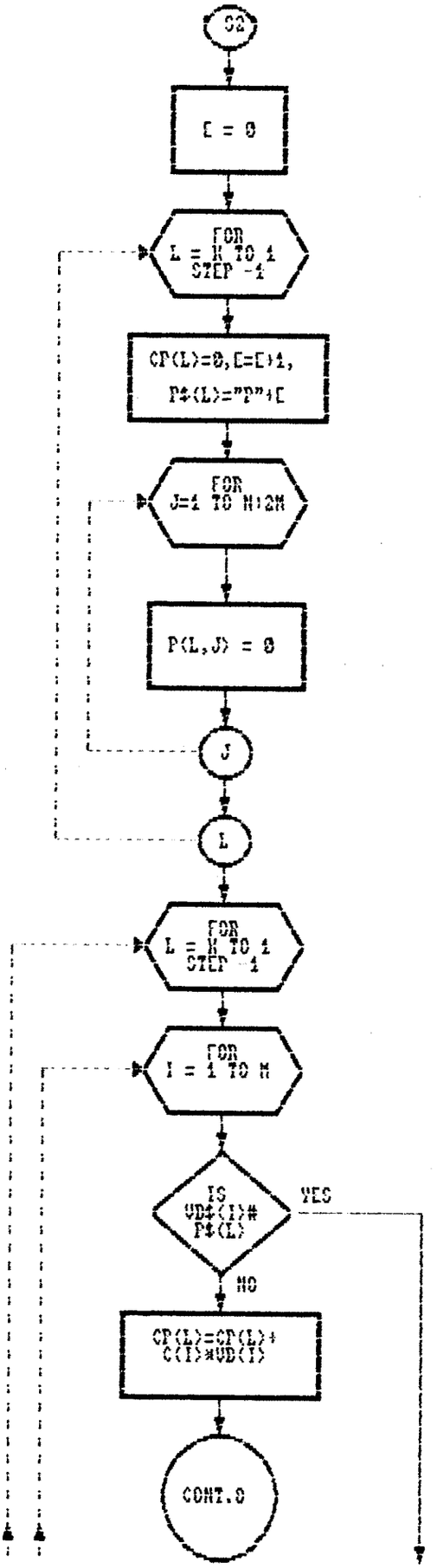

CONT.4
FOR J=1 TO N+2M
GET A(I,J)
J
I
C1
C2
FOR L = K TO 1 STEP -1
MAX = 0
FOR J=1 TO N+2M
IS T(L,J) <=0
YES
IS MAX>T(L,J)
YES
FOR NL=K TO L+1 STEP -1
CONT.5

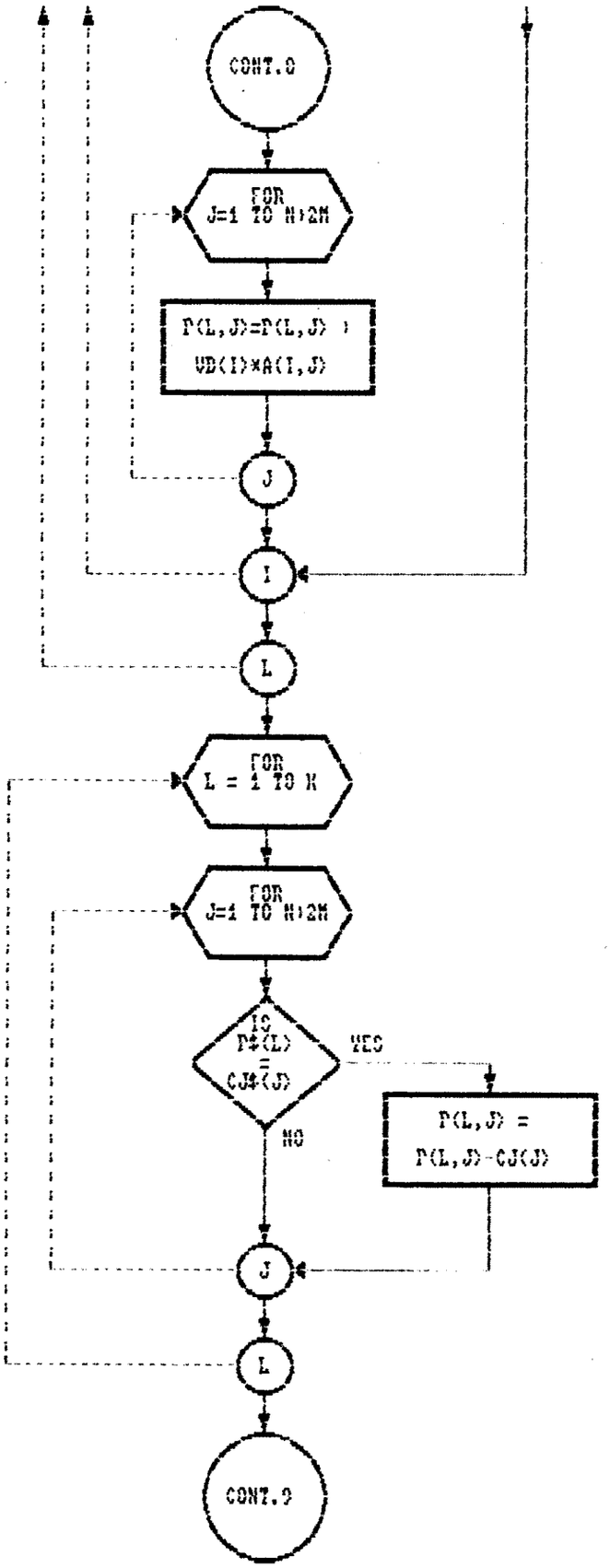

CONT.5
IS P(NL,J) (0
NL
MAX=P(L,J)
W = J
J
IS MAX=0
YES
NO
EQLP = 0
FOR J=1 TO N+2M
IS P(L,J) (= 0
YES
NO
IS P(L,J) # MAX
YES
NO
DCI = 0
DCI(J) = MAX
EQLP=EQLP+1
J
CONT.6

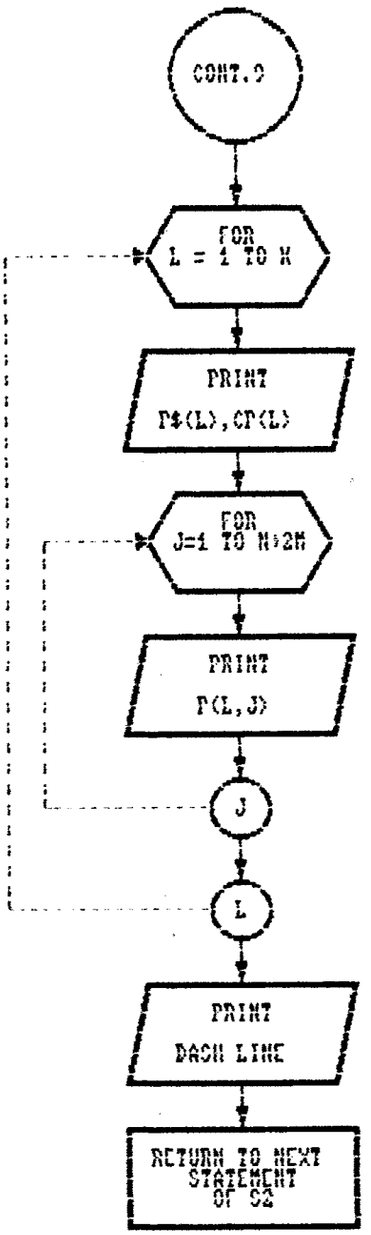

CONT.6
IC
EQLT = 0
YES
NO
IC
EQLT > 1
YES
NO
S3
S4
S1
S2
L
STOP

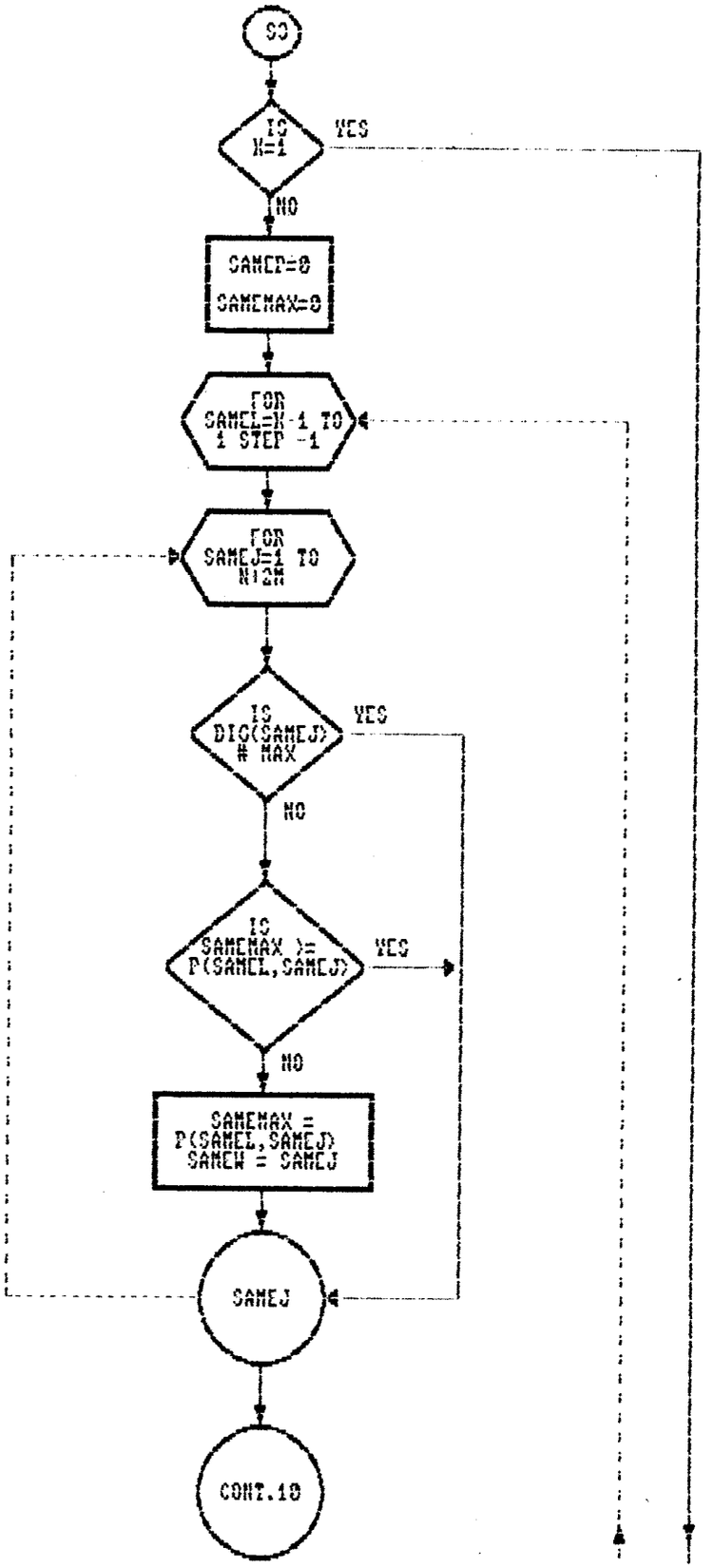

S1
PRINT
DASH LINE
FOR
J=1 TO N+2M
PRINT
CJ(J)
CJ$(J)
J
PRINT
DASH LINE
FOR
J=1 TO N+2M
PRINT
A$(J)
J
PRINT
DASH LINE
CONT.?

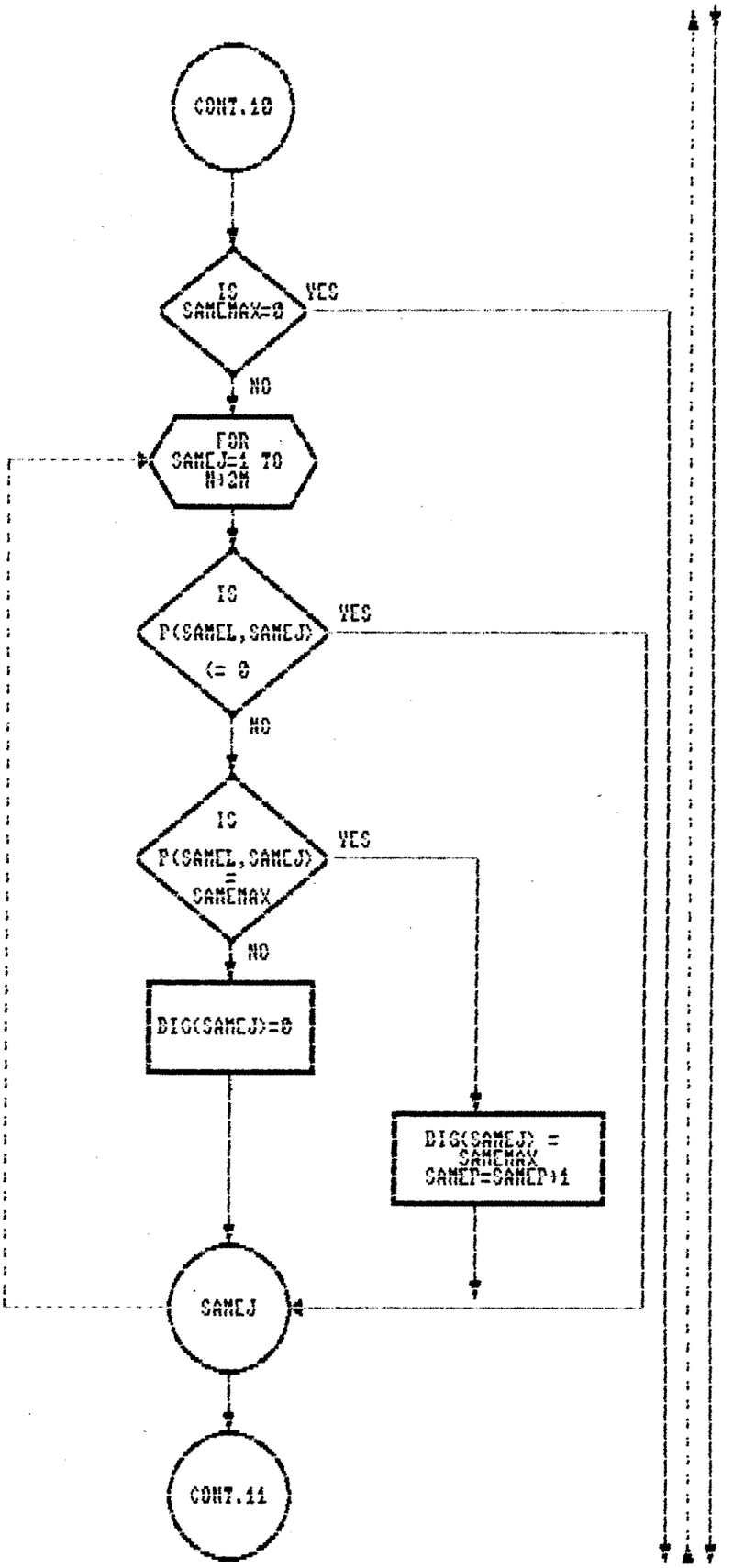

CONT.7
FOR
I = 1 TO N
PRINT VD(I)
VD$(I)
V$(I),C(I)
FOR
J=1 TO N*2N
PRINT
A(I,J)
J
I
PRINT
DASH LINE
RETURN TO
NEXT ST.OF
S1

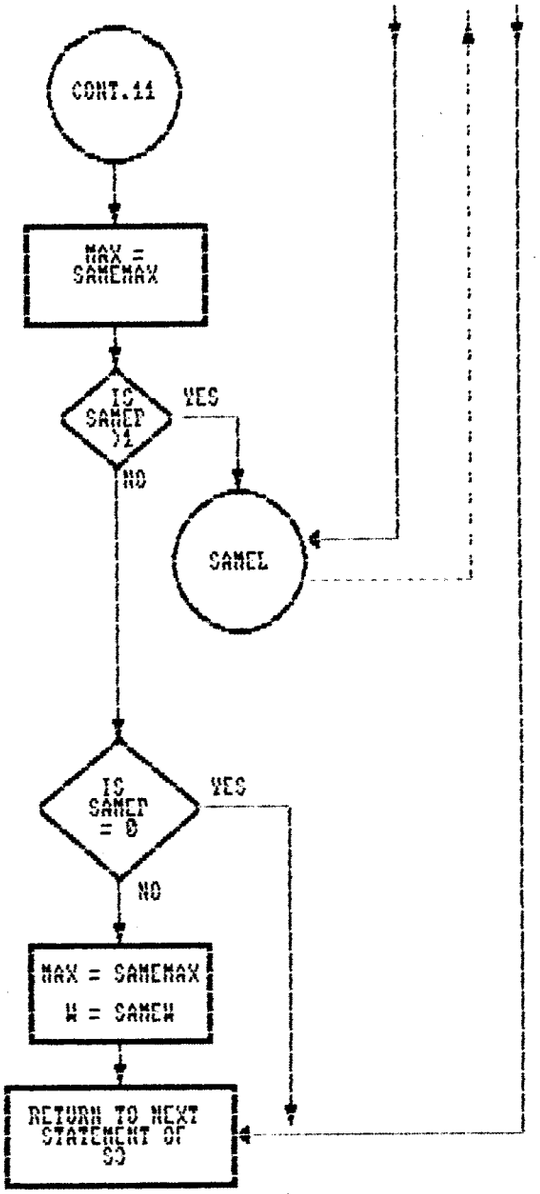

GS
E = 0
FOR
L = N TO 1
STEP -1
CP(L)=0,E=E+1,
P$(L)="P"+E
FOR
J=1 TO N+2N
P(L,J) = 0
J
L
FOR
L = N TO 1
STEP -1
FOR
I = 1 TO N
IS
VD$(I)#
P$(L)
YES
NO
CP(L)=CP(L)+
C(I)*VD(I)
CONT.O

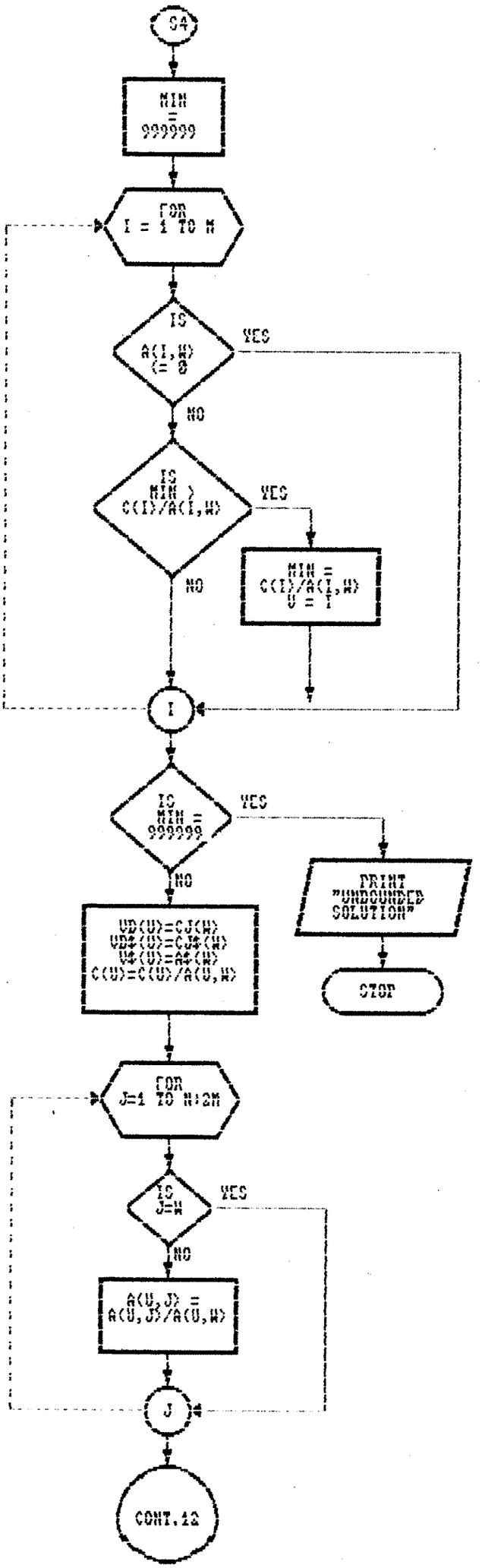

CONT.0
FOR J=1 TO N*2M
P(L,J)=P(L,J) + WD(I)*A(I,J)
J
I
L
FOR L = 1 TO K
FOR J=1 TO N*2M
IS P$(L) = CJ$(J)
YES
NO
P(L,J) = P(L,J)-CJ(J)
J
L
CONT.0

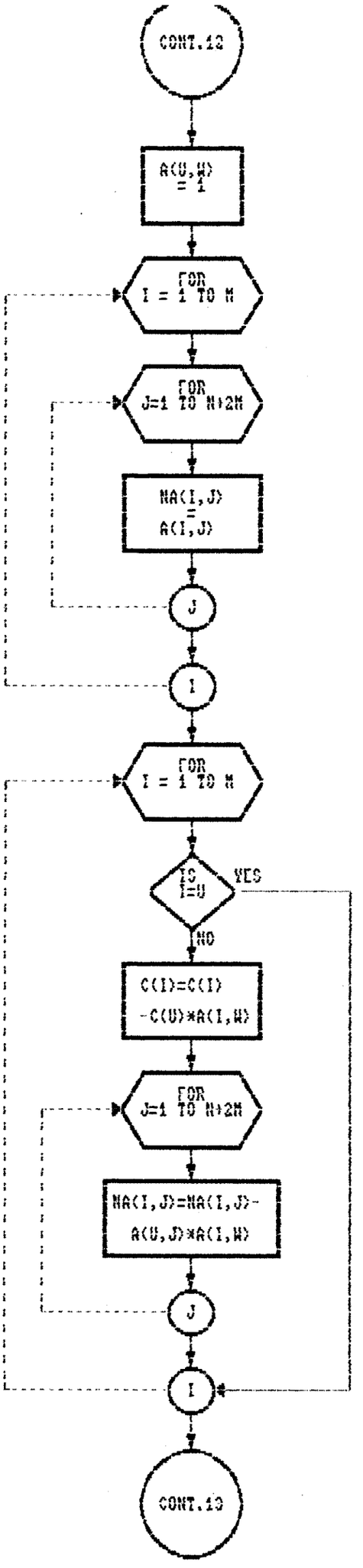

CONT.9
FOR
L = 1 TO M
PRINT
P$(L),CP(L)
FOR
J=1 TO N+2M
PRINT
P(L,J)
J
L
PRINT
DASH LINE
RETURN TO NEXT
STATEMENT
OF S2

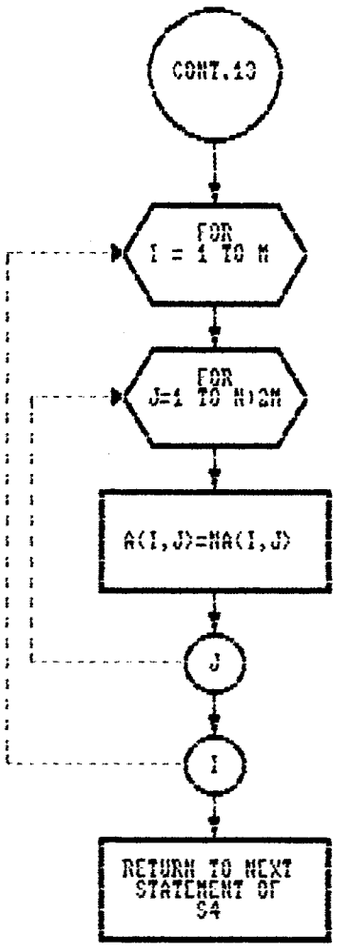

SC
IS N=1
YES
NO
SAMEP=0
SAMEMAX=0
FOR SAMEI=N-1 TO 1 STEP -1
FOR SAMEJ=1 TO N12M
IS DIG(SAMEJ) # MAX
YES
NO
IS SAMEMAX >= P(SAMEI,SAMEJ)
YES
NO
SAMEMAX = P(SAMEI,SAMEJ)
SAMEW = SAMEJ
SAMEJ
CONT.10


CONT.10
IS SAMEMAX=0
YES
NO
FOR SAMEJ=1 TO N+2M
IS P(SAMEI,SAMEJ) (= 0
YES
NO
IS P(SAMEI,SAMEJ) = SAMEMAX
YES
NO
DIG(SAMEJ)=0
DIG(SAMEJ) = SAMEMAX
SAMEJ=SAMEJ+1
SAMEJ
CONT.11


CONT.11
MAX = SAMEMAX
IS SAMEP = 1
YES
NO
SAME1
IS SAMEP = 0
YES
NO
MAX = SAMEMAX
M = SAMEM
RETURN TO NEXT STATEMENT OF SS


S4
MIN = 999999
FOR I = 1 TO M
IS A(I,W) <= 0
YES
NO
IS MIN > C(I)/A(I,W)
YES
MIN = C(I)/A(I,W) U = I
NO
I
IS MIN = 999999
YES
NO
PRINT "UNBOUNDED SOLUTION"
STOP
UB(U)=CJ(W)
UB$(U)=CJ$(W)
V$(U)=A$(W)
C(U)=C(U)/A(U,W)
FOR J=1 TO N+2M
IS J=W
YES
NO
A(U,J) = A(U,J)/A(U,W)
J
CONT.12


CONT.12
A(U,W) = 1
FOR I = 1 TO M
FOR J=1 TO N+2M
NA(I,J) = A(I,J)
J
I
FOR I = 1 TO M
IS I=U
YES
NO
C(I)=C(I) -C(U)*A(I,W)
FOR J=1 TO N+2M
NA(I,J)=NA(I,J)- A(U,J)*A(I,W)
J
I
CONT.13


CONT.13
FOR
I = 1 TO M
FOR
J=1 TO N!2M
A(I,J)=NA(I,J)
J
I
RETURN TO NEXT
STATEMENT OF
SA

```
10  REM ************************************************************
20  REM ***            GOAL PROGRAMMING PACKAGE                  ***
30  REM ***            ~~~~~~~~~~~~~~~~~~~~~~~                   ***
40  REM ***  ---------------------------------------------------  ***
50  REM ***  |  Program Developed    ***   Under Guidance      |  ***
60  REM ***  |                       ***                       |  ***
70  REM ***  |        By             ***       Of              |  ***
80  REM ***  |                       ***                       |  ***
90  REM ***  |     R. M. Patil       ***   Dr. R. V. Kulkarni  |  ***
100 REM ***  ---------------------------------------------------  ***
110 REM ***                                                      ***
140 REM ************************************************************
150 CLS
160 KEY OFF
170 SCREEN 2
180 LOCATE 1,30:PRINT "GOAL PROGRAMMING PACKAGE"
190 LOCATE 2,1
200 REM *** Horizontal Lines ***
210 LINE (35,8) - (600,8)
220 LINE (35,24) - (600,24)
230 LINE (35,40) - (600,40)
240 LINE (35,41) - (600,41)
250 LINE (35,80) - (600,80)
260 LINE (35,110) - (600,110)
270 REM *** Vertical   Lines ***
280 LINE (35,8) - (35,110)
290 LINE (70,8) - (70,110)
300 LINE (100,8) - (100,110)
310 LINE (130,8) - (130,110)
320 LINE (132,8) - (132,110)
330 LINE (600,8) - (600,110)
```

```
340  LOCATE 3,35:PRINT "CJ(N+2M) & CJ$(N+2M)"
350  LOCATE 5,40:PRINT "A$(N+2M)"
360  LOCATE 7,6:PRINT "VB"
370  LOCATE 8,6:PRINT "&"
380  LOCATE 9,6:PRINT "VB$"
390  LOCATE 8,10:PRINT "V$"
400  LOCATE 8,15:PRINT "C"
410  LOCATE 8,40:PRINT "A(M,N+2M)"
420  LOCATE 12,10:PRINT "P$"
430  LOCATE 12,14:PRINT "CP"
440  LOCATE 12,40:PRINT "P(K,N+2M)"
450  LOCATE 15,10:PRINT "1. For Creation of data file...   "
460  LOCATE 17,10:PRINT "2. For Processing.............   "
470  LOCATE 19,10:PRINT "3. Exit.......................   "
480  LOCATE 21,10:INPUT "   Enter any option...........   ",OP
490  IF OP = 3 THEN CLS:STOP:END
500  IF OP = 1 THEN CHAIN "GOAL01.BAS"
510  IF OP = 2 THEN CHAIN "GOAL02.BAS"
520  GOTO 450
```

```
10  REM ************************************************************
20  REM ***              GOAL PROGRAMMING PACKAGE                  ***
30  REM ***              ~~~~~~~~~~~~~~~~~~~~~~~~                  ***
40  REM ***  ---------------------------------------------------   ***
50  REM ***  ¦ Program Developed    ***   Under Guidance       ¦   ***
60  REM ***  ¦                      ***                        ¦   ***
70  REM ***  ¦        By            ***        Of              ¦   ***
80  REM ***  ¦                      ***                        ¦   ***
90  REM ***  ¦    R. M. Patil       ***   Dr. R. V. Kulkarni   ¦   ***
100 REM ***  ---------------------------------------------------   ***
110 REM ***                                                        ***
120 REM ************************************************************
130 REM ***                                                        ***
140 REM *** Working Counters                                       ***
150 REM ***                                                        ***
160 REM ***~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~***
170 REM *** M  - Number Of Constraints                             ***
180 REM *** N  - Number Of Variables                               ***
190 REM *** K  - Number Of Priorities                              ***
200 REM *** CJ - Array For Cost Of Variables                       ***
210 REM *** CJ$- Array For Names Of Cost Of Variables              ***
220 REM *** A$ - Array For Names Of Variables                      ***
230 REM *** VB - Array For Cost Of Basic Variables                 ***
240 REM *** VB$- Array For Names Of Cost Of Basic Variables        ***
250 REM *** V$ - Array For Basic Variables                         ***
260 REM *** C  - Array For Initial Values Of Basic Variables       ***
270 REM *** A  - Array For Technical Coefficient Of Variables      ***
280 REM ***~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~***
290 REM *** CREATION OF FILE FOR INPUT INFORMATION                 ***
300 REM ************************************************************
```

```
310  CLS:KEY OFF
320  DIM CJ(50),CJ$(50),A$(50),VB(50),VB$(50),V$(50),C(50),A(50,50)
330  LOCATE 3,25:PRINT "Input File Creation Program"
340  LOCATE 5,10 :PRINT "Enter File Name.....       ";
350  INPUT NM$
360  LOCATE 20 ,10 :PRINT "Are You Sure (Y/N/E)....   ";
370  INPUT YN$
380  IF YN$ =  "E" OR YN$ =  "e" THEN CHAIN "GOAL.BAS"
390  IF YN$ <> "Y" AND YN$ <> "y" THEN 340
400  OPEN "O",#1,NM$
410  CLS
420  LOCATE 3,25:PRINT "Input File Creation Program"
430  GOSUB 1150
440  LOCATE 20,10 :PRINT "Enter No. Of Constraints..(M)"
450  LOCATE 20,50 :INPUT M
460  LOCATE 20,10 :PRINT "Enter No. Of Variables....(N)"
470  LOCATE 20,50 :INPUT N
480  LOCATE 20,10 :PRINT "Enter No. Of Priorities...(K)"
490  LOCATE 20,50 :INPUT K
500  LOCATE 20,10 :PRINT "Are You Sure (Y/N/E)........."
510  LOCATE 20,50 :INPUT YN$
520  IF YN$ =  "E" OR YN$ =  "e" THEN CLOSE(1):CHAIN "GOAL.BAS"
530  IF YN$ <> "Y" AND YN$ <> "y" THEN 440
540  PRINT #1, "Values Of M, N & K"
550  PRINT #1, M
560  PRINT #1, N
570  PRINT #1, K
580  PRINT #1, "Values Of CJ(N+2M)"
590  FOR J = 1 TO (N + 2 * M)
600      LOCATE 20,10 :PRINT "Enter Cost Of Variables                CJ(";J;")   ";
```

```
610      INPUT CJ(J)
620      PRINT #1, CJ(J)
630  NEXT J
640  PRINT #1, "Values Of CJ$(N+2M)"
650  FOR J = 1 TO (N + 2 * M)
660      LOCATE 20,10 :PRINT "Enter Name Of Cost Of Variables          CJ$(";J;")   ";
670      INPUT CJ$(J)
680      PRINT #1, CJ$(J)
690  NEXT J
700  PRINT #1, "Values Of A$(N+2M)"
710  FOR J = 1 TO (N + 2 * M)
720      LOCATE 20,10 :PRINT "Enter Names Of Variables                 A$(";J;")   ";
730      INPUT A$(J)
740      PRINT #1, A$(J)
750  NEXT J
760  PRINT #1, "Values Of VB(M)"
770  FOR I = 1 TO M
780      LOCATE 20,10 :PRINT "Enter Cost Of Basic Variables            VB(";I;")   ";
790      INPUT VB(I)
800      PRINT #1, VB(I)
810  NEXT I
820  PRINT #1, "Values Of VB$(M)"
830  FOR I = 1 TO M
840      LOCATE 20,10 :PRINT "Enter Names Of Basic Variables           VB$(";I;")   ";
850      INPUT VB$(I)
860      PRINT #1, VB$(I)
870  NEXT I
880  PRINT #1, "Values Of V$(M)"
890  FOR I = 1 TO M
900      LOCATE 20,10 :PRINT "Enter Basic Variables                    V$(";I;")   ";
```

```
910       INPUT V$(I)
920       PRINT #1, V$(I)
930   NEXT I
940   PRINT #1, "Values Of C(M)"
950   FOR I = 1 TO M
960       LOCATE 20,10 :PRINT "Enter Initial Values Of Basic Variables   C(";I;")   ";
970       INPUT C(I)
980       PRINT #1, C(I)
990   NEXT I
1000  PRINT #1, "Values Of A(M..N+2M)"
1010  FOR I = 1 TO M
1020      FOR J = 1 TO N + 2 * M
1030          LOCATE 20,10 :PRINT "Enter Values Of Tech. Coeff. Of Variables A(";I;",";J;")   ";
1040          INPUT A(I,J)
1050          PRINT #1, A(I,J)
1060      NEXT J
1070  NEXT I
1080  CLOSE(1)
1090  CLS
1100  LOCATE 20 ,10 :PRINT "T H A N K   Y O U"
1110  LOCATE 22,10 :PRINT "S E E   Y O U   A G A I N"
1120  CHAIN "GOAL.BAS"
1130  END
1140  REM *** E N D   O F   P R O G R A M E ***
1150  SCREEN 2
1160  CLS:KEY OFF
1170  LOCATE 1,25:PRINT "Input File Creation Program"
1180  LOCATE 2,1
1190  REM *** Horizontal Lines ***
1200  LINE (35,8) - (600,8)
```

```
1210 LINE (35,24) - (600,24)
1220 LINE (35,40) - (600,40)
1230 LINE (35,41) - (600,41)
1240 LINE (35,80) - (600,80)
1250 LINE (35,110) - (600,110)
1260 REM *** Vertical   Lines ***
1270 LINE (35,8) - (35,110)
1280 LINE (70,8) - (70,110)
1290 LINE (100,8) - (100,110)
1300 LINE (130,8) - (130,110)
1310 LINE (132,8) - (132,110)
1320 LINE (600,8) - (600,110)
1330 LOCATE 3,35:PRINT "CJ(N+2M) & CJ$(N+2M)"
1340 LOCATE 5,40:PRINT "A$(N+2M)"
1350 LOCATE 7,6:PRINT "VB"
1360 LOCATE 8,6:PRINT "&"
1370 LOCATE 9,6:PRINT "VB$"
1380 LOCATE 8,10:PRINT "V$"
1390 LOCATE 8,15:PRINT "C"
1400 LOCATE 8,40:PRINT "A(M,N+2M)"
1410 LOCATE 12,10:PRINT "P$"
1420 LOCATE 12,14:PRINT "CP"
1430 LOCATE 12,40:PRINT "P(K,N+2M)"
1440 RETURN
```

```
10    REM ************************************************************************
20    REM ***              GOAL PROGRAMMING PACKAGE                            ***
30    REM ***              ~~~~~~~~~~~~~~~~~~~~~~~~                            ***
40    REM ***    ---------------------------------------------------           ***
50    REM ***    |  Program Developed     ***   Under Guidance       |         ***
60    REM ***    |                        ***                        |         ***
70    REM ***    |         By             ***         Of             |         ***
80    REM ***    |                        ***                        |         ***
90    REM ***    |     R. M. Patil        ***   Dr. R. V. Kulkarni   |         ***
100   REM ***    ---------------------------------------------------           ***
110   REM ***                                                                   ***
120   REM ************************************************************************
130   REM ***                                                                   ***
140   REM *** Working Counters                                                  ***
150   REM ***                                                                   ***
160   REM ***~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~***
170   REM *** M       - Number Of Constraints                                   ***
180   REM *** N       - Number Of Variables                                     ***
190   REM *** K       - Number Of Priorities                                    ***
200   REM *** CJ      - Array For Cost Of Variables                             ***
210   REM *** CJ$     - Array For Names Of Cost Of Variables                    ***
220   REM *** A$      - Array For Names Of Variables                            ***
230   REM *** VB      - Array For Cost Of Basic Variables                       ***
240   REM *** VB$     - Array For Names Of Cost Of Basic Variables              ***
250   REM *** V$      - Array For Basic Variables                               ***
260   REM *** C       - Array For Initial Values Of Basic Variables             ***
270   REM *** A       = Array For Technical Coefficient Of Variables            ***
280   REM *** CP      - Array For Value Of The Objective Function at Diff.      ***
290   REM ***           Priority Levels                                         ***
300   REM *** P$      - Array For Names Of Zj - Cj at Diff. Priority Levels     ***
```

```
310  REM *** P       = Array For Values Of Zj = Cj at Diff. Priority Levels***
320  REM *** NA      - New Array For Storing Values Of Tech. Coeff.        ***
330  REM *** E       - Variable used for Creating Priority Names           ***
340  REM *** W       - Variable used for Storing Column Position           ***
350  REM *** U       - Variable used for Storing Row Position              ***
360  REM *** MAX     - Variable used for Storing Maximum Value             ***
370  REM *** MIN     - Variable used for Storing Minimum Value             ***
380  REM *** EQLP    - Variable used for Storing Equal Priority            ***
390  REM *** BIG     - Array To Store Value Of MAX                         ***
400  REM *** SAMEL   - Variable used for Storing Value Of L                ***
410  REM *** SAMEJ   - Variable used for Storing Value Of J                ***
420  REM *** SAMEMAX - Variable used for Storing Value Of MAX              ***
430  REM ***~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~***
440  REM *** MAIN PROGRAM FOR GOAL PROGRAMMING                            ***
450  REM ************************************************************************
460  CLS
470  DIM CJ(50),CJ$(50),A$(50),VB(50),VB$(50),V$(50),C(50),A(50,50)
480  DIM CP(50),P$(50),P(50,50),NA(50,50),BIG(50),SAMEBIG(50)
490  LOCATE 3,25:PRINT "Main Program For Goal Programming"
500  LOCATE 5,10:PRINT "Enter Data File Name.....  ";
510  LOCATE 7,10:PRINT "Enter Output Print File Name.....  ";
520  LOCATE 5,60:INPUT NI$
530  LOCATE 7,60:INPUT NO$
540  LOCATE 20,10:PRINT "Are You Sure <Y/N/E>....  ";
550  INPUT YN$
560  IF YN$ =  "E" OR YN$ =  "e" THEN CHAIN "GOAL.BAS"
570  IF YN$ <> "Y" AND YN$ <> "y" THEN 450
580  OPEN "I",#1,NI$
590  OPEN "O",#2,NO$
600  CLS
```

```
610   GOSUB 2910
620   REM                          ***  READ INPUT FILE  ***
630   INPUT #1, MESS$
640   INPUT #1, M
650   INPUT #1, N
660   INPUT #1, K
670   INPUT #1, MESS$
680   FOR J = 1 TO (N + 2 * M)
690       INPUT #1, CJ(J)
700   NEXT J
710   INPUT #1, MESS$
720   FOR J = 1 TO (N + 2 * M)
730       INPUT #1, CJ$(J)
740   NEXT J
750   INPUT #1, MESS$
760   FOR J = 1 TO (N + 2 * M)
770       INPUT #1, A$(J)
780   NEXT J
790   INPUT #1, MESS$
800   FOR I = 1 TO M
810       INPUT #1, VB(I)
820   NEXT I
830   INPUT #1, MESS$
840   FOR I = 1 TO M
850       INPUT #1, VB$(I)
860   NEXT I
870   INPUT #1, MESS$
880   FOR I = 1 TO M
890       INPUT #1, V$(I)
900   NEXT I
```

```
910   INPUT #1, MESS$
920   FOR I = 1 TO M
930       INPUT #1, C(I)
940   NEXT I
950   INPUT #1, MESS$
960   FOR I = 1 TO M
970       FOR J = 1 TO (N + 2 * M)
980           INPUT #1, A(I,J)
990       NEXT J
1000  NEXT I
1010  CLOSE(1)
1020  REM                         ***  READ OVER  ***
1030  REM                         ***  Printing Of Formulated Problem  ***
1040  GOSUB 1450
1050  REM                         ***  Processing & Printing Of  ***
1060  REM                         ***       Priority Matrix      ***
1070  GOSUB 2030
1080  REM                         ***  Calculation For Next Tableau  ***
1090  FOR L = K TO 1 STEP -1
1100      LET MAX = 0
1110      FOR J = 1 TO (N + 2 * M)
1120          IF P(L,J) <= 0 THEN 1190
1130          IF MAX > P(L,J) THEN 1190
1140          FOR NL = K TO (L + 1) STEP -1
1150              IF P(NL,J) < 0 THEN 1190
1160          NEXT NL
1170          LET MAX = P(L,J)
1180          LET W = J
1190      NEXT J
1200      IF MAX = 0 THEN 1370
```

```
1210      LET EQLP = 0
1220      FOR J = 1 TO (N + 2 * M)
1230          IF P(L,J) <= 0 THEN 1270
1240          IF P(L,J) <> MAX THEN BIG(J) = 0 : GOTO 1270
1250          LET BIG(J) = MAX
1260          LET EQLP = EQLP + 1
1270      NEXT J
1280      IF EQLP = 0 THEN 1370
1290      REM                    ***  Processing For Next Lower Priority   ***
1300      REM                    ***  As Values Of MAX Appear More Than 1  ***
1310      IF EQLP > 1 THEN GOSUB 1720
1320      REM                    ***  Processing For Selecting The Key Element  ***
1330      GOSUB 2470
1340      GOSUB 1450
1350      GOSUB 2030
1360      GOTO 1100
1370  NEXT L
1380  CLS
1390  LOCATE 20 ,10 :PRINT "T H A N K   Y O U"
1400  LOCATE 22,10 :PRINT "S E E   Y O U   A G A I N"
1410  CLOSE(2)
1420  CHAIN "GOAL.BAS"
1430  END
1440  REM *** E N D   O F   P R O G R A M E ***
1450  REM ************************************************************************
1460  REM ***    S U B R O U T I N E   F O R   P R I N T I N G            ***
1470  REM ***         F O R M U L A T E D   P R O B L E M                 ***
1480  REM ************************************************************************
1490  PRINT #2, STRING$(132,"-")
1500  PRINT #2, ,,
```

```
1510  FOR J = 1 TO (N + 2 * M)
1520      PRINT #2, CJ(J);CJ$(J);"   ";
1530  NEXT J
1540  PRINT #2,
1550  PRINT #2, STRING$(132,"-")
1560  PRINT #2, ,,
1570  FOR J = 1 TO (N + 2 * M)
1580      PRINT #2, A$(J);"     ";
1590  NEXT J
1600  PRINT #2,
1610  PRINT #2, STRING$(132,"=")
1620  FOR I = 1 TO M
1630      PRINT #2, VB(I);VB$(I);"   ";V$(I);"   ";C(I);"   ",
1640      FOR J = 1 TO (N + 2 * M)
1650          PRINT #2, A(I,J);"     ";
1660      NEXT J
1670      PRINT #2,
1680  NEXT I
1690  PRINT #2, STRING$(132,"-")
1700  RETURN
1710  REM *** E N D   O F   P R O G R A M E ***
1720  REM ************************************************************************
1730  REM ***   S U B R O U T I N E   F O R   S A M E   P R I O R I T Y   ***
1740  REM ************************************************************************
1750  IF K = 1 THEN 2010
1760  LET SAMEMAX = 0
1770  LET SAMEP = 0
1780  FOR SAMEL = K - 1 TO 1 STEP -1
1790      FOR SAMEJ = 1 TO (N + 2 * M)
1800          IF BIG(SAMEJ) <> MAX THEN 1840
```

```
1810          IF SAMEMAX >= P(SAMEL,SAMEJ) THEN 1840
1820          LET SAMEMAX = P(SAMEL,SAMEJ)
1830          LET SAMEW = SAMEJ
1840      NEXT SAMEJ
1850      IF SAMEMAX = 0 THEN 1970
1860      FOR SAMEJ = 1 TO (N + 2 * M)
1870          IF P(SAMEL,SAMEJ) <= 0 THEN 1930
1880          IF P(SAMEL,SAMEJ) = SAMEMAX THEN 1910
1890          LET BIG(SAMEJ) = 0
1900          GOTO 1930
1910          LET BIG(SAMEJ) = SAMEMAX
1920          LET SAMEP = SAMEP + 1
1930      NEXT SAMEJ
1940      LET MAX = SAMEMAX
1950      IF SAMEP > 1 THEN 1970
1960      GOTO 1980
1970  NEXT SAMEL
1980  IF SAMEP = 0 THEN 2010
1990  LET MAX = SAMEMAX
2000  LET W   = SAMEW
2010  RETURN
2020  REM *** E N D   O F   P R O G R A M E ***
2030  REM ************************************************************************
2040  REM ***   S U B R O U T I N E   F O R   P R I N T I N G              ***
2050  REM ***         P R I O R I T Y   T A B L E A U                      ***
2060  REM ************************************************************************
2070  REM                          ***  PROCESSING STARTS  ***
2080  E = 0
2090  REM                          ***  Initialize Values Of P(K, N+2M)  ***
2100  FOR L = K TO 1 STEP -1
```

```
2110      LET CP(L) = 0
2120      LET E = E + 1
2130      LET P$(L) = "P"+MID$(STR$(E),2,2)
2140      FOR J = 1 TO (N + 2 * M)
2150          LET P(L,J) = 0
2160      NEXT J
2170  NEXT L
2180  REM                          ***  Calculation Of CP(K) & P(K, N+2M)  ***
2190  FOR L = K TO 1 STEP -1
2200      FOR I = 1 TO M
2210          IF VB$(I) <> P$(L) THEN 2260
2220          LET CP(L) = CP(L) + C(I) * VB(I)
2230          FOR J = 1 TO (N + 2 * M)
2240              LET P(L,J) = P(L,J) + VB(I) * A(I,J)
2250          NEXT J
2260      NEXT I
2270  NEXT L
2280  REM                          ***  Calculation Of P(K, N+2M) i.e. Zj - Cj  ***
2290  FOR L = 1 TO K
2300      FOR J = 1 TO (N + 2 * M)
2310          IF P$(L) = CJ$(J) THEN P(L,J) = P(L,J) - CJ(J)
2320      NEXT J
2330  NEXT L
2340  REM                          ***  Print Priority Matrix  ***
2350  FOR L = 1 TO K
2360      PRINT #2, "         ";P$(L),CP(L),
2370      FOR J = 1 TO (N + 2 * M)
2380          PRINT #2, P(L,J);"     ";
2390      NEXT J
2400      PRINT #2,
```

```
2410  NEXT L
2420  PRINT #2,
2430  PRINT #2, STRING$(132,"-")
2440  PRINT #2, : PRINT #2, : PRINT #2, : PRINT #2, : PRINT #2,
2450  RETURN
2460  REM *** E N D   O F   P R O G R A M E ***
2470  REM ************************************************************************
2480  REM ***   S U B R O U T I N E   F O R   S E L E C T I N G          ***
2490  REM ***          T H E   K E Y   E L E M E N T                     ***
2500  REM ************************************************************************
2510  LET MIN = 999999!
2520  FOR I = 1 TO M
2530      IF A(I,W) <= 0 THEN 2550
2540      IF MIN > C(I) / A(I,W) THEN LET MIN = C(I) / A(I,W) : LET U = I
2550  NEXT I
2560  IF MIN = 999999! THEN PRINT #2, "Unbounded Solution":GOTO 1390
2570  REM                         ***  Transformation Of New Values  ***
2580  REM                         ***  Of Next Tableau Into Original ***
2590  REM                         ***           Variables            ***
2600  LET VB(U)  = CJ(W)
2610  LET VB$(U) = CJ$(W)
2620  LET V$(U)  = A$(W)
2630  LET C(U)   = C(U) / A(U,W)
2640  FOR J = 1 TO (N + 2 * M)
2650      IF J = W THEN 2670
2660      LET A(U,J) = A(U,J) / A(U,W)
2670  NEXT J
2680  LET A(U,W) = 1
2690  FOR I = 1 TO M
2700      FOR J = 1 TO (N + 2 * M)
```

```
2710          LET NA(I,J) = A(I,J)
2720      NEXT J
2730  NEXT I
2740  FOR I = 1 TO M
2750      IF I = U THEN 2800
2760      LET C(I) = C(I) - C(U) * A(I,W)
2770      FOR J = 1 TO (N + 2 * M)
2780          LET NA(I,J) = NA(I,J) - A(U,J) * A(I,W)
2790      NEXT J
2800  NEXT I
2810  FOR I = 1 TO M
2820      FOR J = 1 TO (N + 2 * M)
2830          LET A(I,J) = NA(I,J)
2840      NEXT J
2850  NEXT I
2860  LOCATE 20,30:PRINT RRP;" Iteration is Over"
2870  LOCATE 22,30:INPUT "Strick Any Key To Continue ",RMP
2880  LET RRP = RRP + 1
2890  RETURN
2900  REM *** E N D   O F   P R O G R A M E ***
2910  REM *** Subroutine for screen ***
2920  CLS
2930  KEY OFF
2940  SCREEN 2
2950  LOCATE 1,25:PRINT "Main Program For Goal Programming"
2960  LOCATE 2,1
2970  REM *** Horizontal Lines ***
2980  LINE (35,8) - (600,8)
2990  LINE (35,24) - (600,24)
3000  LINE (35,40) - (600,40)
```

```
3010  LINE (35,41) - (600,41)
3020  LINE (35,80) - (600,80)
3030  LINE (35,110) - (600,110)
3040  REM *** Vertical   Lines ***
3050  LINE (35,8) - (35,110)
3060  LINE (70,8) - (70,110)
3070  LINE (100,8) - (100,110)
3080  LINE (130,8) - (130,110)
3090  LINE (132,8) - (132,110)
3100  LINE (600,8) - (600,110)
3110  LOCATE 3,35:PRINT "CJ(N+2M) & CJ$(N+2M)"
3120  LOCATE 5,40:PRINT "A$(N+2M)"
3130  LOCATE 7,6:PRINT "VB"
3140  LOCATE 8,6:PRINT "&"
3150  LOCATE 9,6:PRINT "VB$"
3160  LOCATE 8,10:PRINT "V$"
3170  LOCATE 8,15:PRINT "C"
3180  LOCATE 8,40:PRINT "A(M,N+2M)"
3190  LOCATE 12,10:PRINT "P$"
3200  LOCATE 12,14:PRINT "CP"
3210  LOCATE 12,40:PRINT "P(K,N+2M)"
3220  RETURN
```

5.4 Computer Output :—

The following table represents the data regarding first sector concerning Control Points Bhawani Mandap and Shivaji Maidan.

T A B L E - I

I. B. M. / S. P.	Passengers	Trips	Km.	Revenue	Time
1. Sugar mill	1505	30	7.00	2333.00	25
2. Apate Nagar	1386	42	4.50	1682.75	15
3. Katyayani	659	18	9.50	384.50	30
4. Salokhe Nagar	1217	25	4.60	1877.75	20
5. Vashi	825	28	9.50	1498.00	30
6. University Colony	1179	32	6.00	1679.25	25
7. University	865	30	6.00	1259.00	20
8. Rajarampuri	994	40	4.00	1450.00	15
9. K.I.T.	860	44	9.50	1207.75	30
10. Samrat Nagar	759	32	4.50	1258.75	20
11. Jarag Nagar	1297	38	4.60	1703.75	20
12. Nana Patil Nagar	1386	42	4.50	1682.75	20
1. Kadamwadi	1467	31	9.10	1955.00	40
2. Market yard	775	26	5.50	575.00	20
3. University	792	28	6.00	1000.25	20
4. Apte Nagar	1389	42	4.00	1610.50	15
	17355	528	98.80	23158.00	365

It is observed from the above table that --

a) Total number of passengers travelled per day - 17,355.00

b) Total number of trips per day - 528.00

c) Total number of Kilometer travelled per day - 98.80

d) Total number of Revenue earned per day - 23,158.00

e) Total number of Time taken in minutes per day - 365.00

The following table represents the data regarding first sector concerning Control Points Gangavesh and Shahu Maidan.

T A B L E - II

II. G. / S. M.	Passengers	Trips	Km.	Revenue	Time
1. Kuditre	1082	21	14.50	2301.00	45
2. Koge	926	22	11.80	1800.00	40
3. Wakare	1400	24	10.50	2711.00	40
4. Hanumantwadi	1537	32	9.90	2665.00	25
5. Padali	616	18	7.80	1164.75	25
6. Shindewadi	1002	22	11.40	1572.75	40
7. Shinganapur	1156	32	7.00	1941.50	25
8. University	601	30	6.00	885.00	25
9. Bavada	1237	22	6.80	1961.00	25
1. Mudshingi	832	22	9.80	1345.50	35
2. Nerle Tamgaon	1198	20	13.20	2325.75	40
3. Kaneri Math	444	14	15.40	824.25	45
4. More wadi	1250	32	6.00	1989.25	25
5. Uchgaon	1014	32	7.30	1525.00	25
6. Lonar Vasahat	286	18	6.70	397.00	25
7. Rajendra Nagar	903	30	6.00	1227.25	25
	15484	391	150.10	26636.00	510

It is observed from the above table that --

a) Total number of passengers travelled per day - 15,484.00

b) Total number of trips per day - 391.00

c) Total number of Kilometer travelled per day - 150.10

d) Total number of Revenue earned per day - 26,636.00

e) Total number of Time taken in minutes per day - 510.00

The following table represents the data regarding first sector concerning Control Points Maharana Pratap Chowk and Sonya Maruti Chowk.

T A B L E - III

III. M. P. C. / S. M. C.	Passengers	Trips	Km.	Revenue	Time
1. Shiye	818	16	17.50	1628.75	50
2. Chinchwad	1168	24	11.00	2119.25	35
3. Waliwade	1599	26	11.00	3109.50	35
4. Koyana Colony	1059	22	11.00	1895.75	35
5. Chokak	843	18	18.00	1731.75	50
1. Jathar Wadi	788	18	13.00	1612.25	40
2. Porle	888	22	14.10	1952.50	40
3. Nitawade	750	26	11.20	1461.00	35
	7913	172	106.80	15510.75	320

It is observed from the above table that --

a) Total number of passengers travelled per day - 7,913.00

b) Total number of trips per day - 172.00

c) Total number of Kilometer travelled per day - 106.80

d) Total number of Revenue earned per day - 15,510.75

e) Total number of Time taken in minutes per day - 320.00

Thus, it is observed that the total data of all the sectors is as follows --

Table - 9

a) Total number of passengers travelled per day - 40,752.00

b) Total number of trips per day - 1,091.00

c) Total number of Kilometer travelled per day - 355.70

d) Total number of Revenue earned per day - 65,304.75

e) Total number of Time taken in minutes per day - 1,195.00

Formulation Of The Problem :-

Let, x1 represents 1st sector i.e. Bhavani Mandap and Shivaji Putla based on sectoral route length.

x2 represents 2nd sector i.e. Gangavesh and Shahu Maidan based on sectoral route length.

x3 represents 3rd sector i.e. Maharana Pratap Chowk and Sonya Maruti Chowk based on sectoral route length.

d1 represents positive deviation from goal 1

d2 represents positive deviation from goal 2

d3 represents positive deviation from goal 3

d1 represents negative deviation from goal 1

d2 represents negative deviation from goal 2

d3 represents negative deviation from goal 3

Thus, the objective function (Z) becomes --

$$\text{Minimize, } Z = P1(d1^- + d3^+) + P2\ d2^+ + P3\ d3^+$$

Subject to Goal Constraints,

Occupancy Constraint :-

$$32.87x1 + 39.60x2 + 46.01x3 + d1^- - d1^+ = 1494.12$$

Revenue Constraint :-

$$43.86x1 + 68.12x2 + 90.18x3 + d2^- - d2^+ = 2394.31$$

Bus Availability Constraint :-

$$1.00x1 + 1.00x2 + 1.00x3 + d3^- - d3^+ = 40.00$$

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	1494.120	32.87	39.60	46.01	1	0	0	0	0	0
1 P2	d2-	2394.310	43.86	68.12	90.18	0	1	0	0	0	0
1 P3	d3-	40.000	1.00	1.00	1.00	0	0	1	0	0	-1
	P3	40.000	1	1	1	0	0	0	0	0	-1
	P2	2394.310	43.86	68.12	90.18	0	0	0	0	0	0
	P1	1494.120	32.87	39.60	46.01	0	0	0	0	0	-1

1st Iteration

			0 —	0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	272.539	10.49	4.85	0	1	-0.51	0	0	0	0
0 —	.x3	26.550	0.49	0.76	1	0	0.01	0	0	0	0
1 P3	d3-	13.450	0.51	0.24	0	0	-0.01	1	0	0	-1
	P3	13.450	0.51	0.24	0	0	-0.01	0	0	0	-1
	P2	0.000	0.00	0.00	0	0	-1.00	0	0	0	0
	P1	272.539	10.49	4.85	0	0	-0.51	0	0	0	-1

2nd Iteration

			Ø —	Ø —	Ø —	1 P1	1 P2	1 P3	Ø —	Ø —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
Ø —	.x1	25.975	1	Ø.46	Ø	Ø.10	-Ø.Ø5	Ø	Ø	Ø	Ø
Ø —	.x3	13.917	Ø	Ø.53	1	-Ø.Ø5	Ø.Ø3	Ø	Ø	Ø	Ø
1 P3	d3-	Ø.1Ø8	Ø	Ø.Ø1	Ø	-Ø.Ø5	Ø.Ø1	1	Ø	Ø	-1
	P3	Ø.1Ø8	Ø	Ø.Ø1	Ø	-Ø.Ø5	Ø.Ø1	Ø	Ø	Ø	-1
	P2	Ø	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø
	P1	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø	-1

3rd Iteration

			Ø —	Ø —	Ø —	1 P1	1 P2	1 P3	Ø —	Ø —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
Ø —	.x1	19.266	1	Ø	Ø	3.13	-Ø.91	-62.Ø4	Ø	Ø	62.Ø4
Ø —	.x3	6.2Ø6	Ø	Ø	1	3.44	-Ø.96	-71.31	Ø	Ø	71.31
Ø —	.x2	14.527	Ø	1	Ø	-6.58	1.87	134.35	Ø	Ø	-134.35
	P3	Ø	Ø	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø
	P2	Ø	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø
	P1	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø	-1

Hence, the optimal solution obtained is --

$x1 = 19$

$x2 = 15$

$x3 = 6$

So in order to maximize occupancy, revenue the Kolhapur Municipal Transport should run 19 buses to sector 1 i.e. Bhawani Mandap and Shivaji Putla, 15 buses to sector 2 i.e. Gangavesh and Shahu Maidan and 6 buses to sector 3 i.e. Maharana Pratap Chowk and Sonya Maruti Chowk.

The following table represents the data regarding first sector concerning Control Points Bhawani Mandap and Shivaji Putla.

T A B L E - IV

	1	2	3	4	5
I. BHAVANI MANDAP	Passengers	Trips	Km.	Revenue	Time
1. Sugar mill	1505	30	7.00	2333.00	25
2. Apate Nagar	1386	42	4.50	1682.75	15
3. Katyayani	659	18	9.50	384.50	30
4. Salokhe Nagar	1217	25	4.60	1877.75	20
5. Vashi	825	28	9.50	1498.00	30
6. University Colony	1179	32	6.00	1679.25	25
7. University	865	30	6.00	1259.00	20
8. Rajarampuri	994	40	4.00	1450.00	15
9. K.I.T.	860	44	9.50	1207.75	30
10. Samrat Nagar	759	32	4.50	1258.75	20
11. Jarag Nagar	1297	38	4.60	1703.75	20
12. Nana Patil Nagar	1386	42	4.50	1682.75	20
	12932	401	74.20	18017.25	270
II. SHIVAJI PUTLA	Passengers	Trips	Km.	Revenue	Time
1. Kadamwadi	1467	31	9.10	1955.00	40
2. Market yard	775	26	5.50	575.00	20
3. University	792	28	6.00	1000.25	20
4. Apte Nagar	1389	42	4.00	1610.50	15
	4423	127	24.60	5140.75	95
TOTAL :-	17355	528	98.80	23158.00	365

It is observed from the above table that --

a) Total number of passengers travelled per day - 17,355.ØØ

b) Total number of trips per day - 528.ØØ

c) Total number of Kilometer travelled per day - 98.8Ø

d) Total number of Revenue earned per day - 23,158.ØØ

e) Total number of Time taken in minutes per day - 365.ØØ

Formulation Of The Problem For The 1st Sector :-

Let, x1 represents Buses to be run from Bhavani Mandap

x2 represents Buses to be run from Shivaji Putla

d1 represents positive deviation from goal 1

d2 represents positive deviation from goal 2

d1 represents negative deviation from goal 1

d2 represents negative deviation from goal 2

Thus, the objective function (Z) becomes --

Minimize, $Z = P1(d1 + d2) + P2\ d2$

Subject to Goal Constraints,

Occupancy Constraint :-

$$32.25x1 + 34.83x2 + d1- - d1+ = 624.52$$

Revenue Constraint :-

$$44.93x1 + 4Ø.48x2 + d2- - d2+ = 833.34$$

Bus Availability Constraint :-

$$1.ØØx1 + 1.ØØx2 + d3- - d3+ = 19.ØØ$$

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	624.520	32.25	34.38	1	0	0	0	0	0
1 P2	d2-	833.340	44.93	40.48	0	1	0	0	0	0
1 P3	d3-	19.000	1.00	1.00	0	0	1	0	0	-1
	P3	19.000	1	1	0	0	0	0	0	-1
	P2	833.340	44.93	40.48	0	0	0	0	0	0
	P1	624.520	32.25	34.38	0	0	0	0	0	-1

1st Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x2	18.165	0.938	1	0.029	0	0	0	0	0
1 P2	d2-	98.012	6.958	0	-1.177	1	0	0	0	0
1 P3	d3-	0.835	0.062	0	-0.029	0	1	0	0	-1
	P3	0.835	0.062	0	-0.029	0	0	0	0	-1
	P2	98.012	6.958	0	-1.177	0	0	0	0	0
	P1	0.000	0.000	0	-1.000	0	0	0	0	-1

2nd Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x2	5.526	0	1	.469	0	-15.141	0	0	15.141
1 P2	d2-	4.260	0	0	2.089	1	-112.307	0	0	112.307
0 —	.x1	13.474	1	0	-.469	0	16.141	0	0	-16.141
	P3	0.000	0	0	0	0	-1	0	0	0
	P2	4.260	0	0	2.089	0	-112.307	0	0	112.307
	P1	0.000	0	0	-1	0	0	0	0	-1

Hence, the optimal solution obtained is --

$x1 = 13$

$x2 = 6$

So in order to maximize occupancy, revenue the Kolhapur Municipal Transport should run 13 buses to Control Ponit 1 i.e. Bhawani Mandap and 6 buses to Control Point 2 i.e. Shivaji Putla.

The following table represents the data regarding second sector concerning Control Points Gangavesh and Shahu Maidan.

T A B L E - V

	1	2	3	4	5
I. GANGAVESH	Passengers	Trips	Km.	Revenue	Time
1. Kuditre	1082	21	14.50	2301.00	45
2. Koge	926	22	11.80	1800.00	40
3. Wakare	1400	24	10.50	2711.00	40
4. Hanumantwadi	1537	32	9.90	2665.00	25
5. Padali	616	18	7.80	1164.75	25
6. Shindewadi	1002	22	11.40	1572.75	40
7. Shinganapur	1156	32	7.00	1941.50	25
8. University	601	30	6.00	885.00	25
9. Bavada	1237	22	6.80	1961.00	25
	9557	223	85.70	17002.00	290
II. SHAHU MAIDAN	Passengers	Trips	Km.	Revenue	Time
1. Mudshingi	832	22	9.80	1345.50	35
2. Nerle Tamgaon	1198	20	13.20	2325.75	40
3. Kaneri Math	444	14	15.40	824.25	45
4. More wadi	1250	32	6.00	1989.25	25
5. Uchgaon	1014	32	7.30	1525.00	25
6. Lonar Vasahat	286	18	6.70	397.00	25
7. Rajendra Nagar	903	30	6.00	1227.25	25
	5927	168	64.40	9634.00	220
TOTAL :-	15484	391	150.10	26636.00	510

It is observed from the above table that --

a) Total number of passengers travelled per day - 15,484.ØØ

b) Total number of trips per day - 391.ØØ

c) Total number of Kilometer travelled per day - 15Ø.1Ø

d) Total number of Revenue earned per day - 26,636.ØØ

e) Total number of Time taken in minutes per day - 51Ø.ØØ

Formulation Of The Problem For The 2nd Sector :-

Let, x1 represents Buses to be run from Gangavesh

x2 represents Buses to be run from Shahu Maidan

d1 represents positive deviation from goal 1

d2 represents positive deviation from goal 2

d1 represents negative deviation from goal 1

d2 represents negative deviation from goal 2

Thus, the objective function (Z) becomes --

Minimize, $Z = P1(d1 + d2) + P2\ d2$

Subject to Goal Constraints,

Occupancy Constraint :-

$$42.86x1 + 35.28x2 + d1- - d1+ = 594.02$$

Revenue Constraint :-

$$76.24x1 + 57.35x2 + d2- - d2+ = 1021.84$$

Bus Availability Constraint :-

$$1.ØØx1 + 1.ØØx2 + d3- - d3+ = 15.ØØ$$

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	594.020	42.86	35.28	1	0	0	0	0	0
1 P2	d2-	1021.840	76.24	57.35	0	1	0	0	0	0
1 P3	d3-	15.000	1	1	0	0	1	0	0	-1
	P3	15.000	1	1	0	0	0	0	0	-1
	P2	1021.840	76.24	57.35	0	0	0	0	0	0
	P1	594.020	42.86	35.28	0	0	0	0	0	-1

1st Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	19.570	0	3.039	1	-0.562	0	0	0	0
0 —	.x1	13.403	1	0.752	0	0.013	0	0	0	0
1 P3	d3-	1.597	0	0.248	0	-0.013	1	0	0	-1
	P3	1.597	0	0.248	0	-0.013	0	0	0	-1
	P2	0.000	0	0.000	0	-1.000	0	0	0	0
	P1	19.570	0	3.039	0	-0.562	0	0	0	-1

2nd Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x2	6.439	0	1	0.329	-0.185	0	0	0	0
0 —	.x1	8.560	1	0	-0.247	0.152	0	0	0	0
1 P3	d3-	0.002	0	0	-0.082	0.033	1	0	0	-1
	P3	0.002	0	0	-0.082	0.032	0	0	0	-1
	P2	0.000	0	0	0	-1	0	0	0	0
	P1	0.000	0	0	-1	0	0	0	0	-1

Hence, the optimal solution obtained is --

$x1 = 9$

$x2 = 6$

So in order to maximize occupancy, revenue the Kolhapur Municipal Transport should run 9 buses to Control Ponit 3 i.e. Gangavesh and 6 buses to Control Point 4 i.e. Shahu Maidan.

The following table represents the data regarding third sector concerning Control Points Maharana Pratap Chowk and Sonya Maruti Chowk.

T A B L E – VI

	1	2	3	4	5
I. MAHARANA PRATAP CHOWK	Passengers	Trips	Km.	Revenue	Time
1. Shiye	818	16	17.50	1628.75	50
2. Chinchwad	1168	24	11.00	2119.25	35
3. Waliwade	1599	26	11.00	3109.50	35
4. Koyana Colony	1059	22	11.00	1895.75	35
5. Chokak	843	18	18.00	1731.75	50
	5487	106	68.50	10485.00	205
II. SONYA MARUTI CHOWK	Passengers	Trips	Km.	Revenue	Time
1. Jathar Wadi	788	18	13.00	1612.25	40
2. Porle	888	22	14.10	1952.50	40
3. Nitawade	750	26	11.20	1461.00	35
	2426	66	38.30	5025.75	115
TOTAL :-	7913	172	106.80	15510.75	320

It is observed from the above table that --

a) Total number of passengers travelled per day - 7,913.ØØ

b) Total number of trips per day - 172.ØØ

c) Total number of Kilometer travelled per day - 1Ø6.8Ø

d) Total number of Revenue earned per day - 15,51Ø.75

e) Total number of Time taken in minutes per day - 32Ø.ØØ

Formulation Of The Problem For The 3rd Sector :-

Let, x1 represents Buses to be run from Maharana Pratap Chowk

x2 represents Buses to be run from Sonya Maruti Chowk

d1 represents positive deviation from goal 1

d2 represents positive deviation from goal 2

d1 represents negative deviation from goal 1

d2 represents negative deviation from goal 2

Thus, the objective function (Z) becomes --

Minimize, $Z = P1(d1^- + d2^-) + P2\ d2^-$

Subject to Goal Constraints,

Occupancy Constraint :-

$$51.76x1 + 36.76x2 + d1^- - d1^+ = 276.03$$

Revenue Constraint :-

$$98.92x1 + 76.15x2 + d2^- - d2^+ = 541.07$$

Bus Availability Constraint :-

$$1.ØØx1 + 1.ØØx2 + d3^- - d3^+ = 6.ØØ$$

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	276.030	51.76	36.76	1	0	0	0	0	0
1 P2	d2-	541.070	98.92	76.15	0	1	0	0	0	0
1 P3	d3-	6.000	1	1	0	0	1	0	0	-1
	P3	6.000	1	1	0	0	0	0	0	-1
	P2	541.070	98.92	76.15	0	0	0	0	0	0
	P1	276.030	51.76	36.76	0	0	0	0	0	-1

1st Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x1	5.333	1	0.710	0.019	0	0	0	0	0
1 P2	d2-	13.541	0	5.897	-1.911	1	0	0	0	0
1 P3	d3-	0.667	0	0.290	-0.019	0	1	0	0	-1
	P3	0.667	0	0.290	-0.019	0	0	0	0	-1
	P2	13.541	0	5.897	-1.911	0	0	0	0	0
	P1	0.000	0	0	-1	0	0	0	0	-1

2nd Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x1	3.702	1	0	0.249	-0.120	0	0	0	0
0 —	.x2	2.296	0	1	-0.324	0.170	0	0	0	0
1 P3	d3-	0.002	0	0	0.075	-0.049	1	0	0	-1
	P3	0.002	0	0	0.075	-0.049	0	0	0	-1
	P2	0.000	0	0	0	-1	0	0	0	0
	P1	0.000	0	0	-1	0	0	0	0	-1

Hence, the optimal solution obtained is --

$x1 = 4$

$x2 = 2$

So in order to maximize occupancy, revenue the Kolhapur Municipal Transport should run 4 buses to Control Ponit 5 i.e. Maharana Pratap Chowk and 2 buses to Control Point 6 i.e. Sonya Maruti Chowk.

Formulation Of The Problem

For Revenue Maximization :-

The same problem may be run even with Revenue as first priority and Occupancy as second priority. Thus, the formulation is as follows --

Let, x1 represents 1st sector i.e. Bhavani Mandap and Shivaji Putla based on sectoral route length.

x2 represents 2nd sector i.e. Gangavesh and Shahu Maidan based on sectoral route length.

x3 represents 3rd sector i.e. Maharana Pratap Chowk and Sonya Maruti Chowk based on sectoral route length.

d1 represents positive deviation from goal 1
d2 represents positive deviation from goal 2
d3 represents positive deviation from goal 3
d1 represents negative deviation from goal 1
d2 represents negative deviation from goal 2
d3 represents negative deviation from goal 3

Thus, the objective function (Z) becomes --

Minimize, $Z = P1(d1 + d3) + P2\ d2 + P3\ d3$

Subject to Goal Constraints,

Revenue Constraint :-

$$43.86x1 + 68.12x2 + 90.18x3 + d2- - d2+ = 2394.31$$

Occupancy Constraint :-

$$32.87x1 + 39.60x2 + 46.01x3 + d1- - d1+ = 1494.12$$

Bus Availability Constraint :-

$$1.00x1 + 1.00x2 + 1.00x3 + d3- - d3+ = 40.00$$

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	2394.310	43.86	68.12	90.18	0	1	0	0	0	0
1 P2	d2-	1494.120	32.87	39.60	46.01	1	0	0	0	0	0
1 P3	d3-	40.000	1	1	1	0	0	1	0	0	-1
	P3	40.000	1	1	1	0	0	0	0	0	-1
	P2	1494.120	32.87	39.6	46.01	1	-1	0	0	0	0
	P1	2394.310	43.86	68.12	90.18	-1	1	0	0	0	-1

1st Iteration

			0 —	0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x3	26.550	0.49	0.76	1	0	0.01	0	0	0	0
1 P2	d2-	272.539	10.49	4.85	0	1	-0.51	0	0	0	0
1 P3	d3-	13.450	0.51	0.24	0	0	-0.01	1	0	0	-1
	P3	13.450	0.51	0.24	0	0	-0.01	0	0	0	-1
	P2	272.539	10.49	4.85	0	1	-1.51	0	0	0	0
	P1	0	0	0	0	-1	0	0	0	0	-1

2nd Iteration

			Ø —	Ø —	Ø —	1 P1	1 P2	1 P3	Ø —	Ø —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
Ø —	.x3	13.917	Ø	0.531	1	-0.05	0.03	Ø	Ø	Ø	Ø
Ø —	.x1	25.975	1	0.462	Ø	0.10	-0.05	Ø	Ø	Ø	Ø
1 P3	d3-	0.108	Ø	0.007	Ø	-0.05	0.01	1	Ø	Ø	-1
	P3	0.108	Ø	0.01	Ø	-0.05	0.01	Ø	Ø	Ø	-1
	P2	Ø	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø
	P1	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø	-1

3rd Iteration

			Ø —	Ø —	Ø —	1 P1	1 P2	1 P3	Ø —	Ø —	1 P1
			.x1	.x2	.x3	d1-	d2-	d3-	d1+	d2+	d3+
Ø —	.x3	6.206	Ø	Ø	1	3.44	-0.96	-71.31	Ø	Ø	71.31
Ø —	.x1	19.266	1	Ø	Ø	3.13	-0.91	-62.04	Ø	Ø	62.04
Ø —	.x2	14.527	Ø	1	Ø	-6.58	1.87	134.35	Ø	Ø	-134.35
	P3	Ø	Ø	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø
	P2	Ø	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø
	P1	Ø	Ø	Ø	Ø	-1	Ø	Ø	Ø	Ø	-1

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	833.340	44.93	40.48	0	1	0	0	0	0
1 P2	d2-	624.520	32.25	34.38	1	0	0	0	0	0
1 P3	d3-	19.000	1	1	0	0	1	0	0	-1
	P3	19.000	1	1	0	0	0	0	0	-1
	P2	624.520	32.25	34.38	1	-1	0	0	0	0
	P1	833.340	44.93	40.48	-1	1	0	0	0	-1

1st Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x1	18.548	1	0.90	0	0.02	0	0	0	0
1 P2	d2-	26.362	0	5.32	1	-0.72	0	0	0	0
1 P3	d3-	0.452	0	0.10	0	-0.02	1	0	0	-1
	P3	0.452	0	0.10	0	-0.02	0	0	0	-1
	P2	26.362	0	5.32	1	-1.72	0	0	0	0
	P1	0.000	0	0	-1	0	0	0	0	-1

2nd Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x1	14.431	1	0	0	0.22	-9.10	0	0	9.10
1 P2	d2-	2.039	0	0	1	0.48	-53.76	0	0	53.76
0 —	.x2	4.569	0	1	0	-0.22	10.10	0	0	-10.10
	P3	0	0	0	0	0	-1	0	0	1
	P2	2.039	0	0	1	-0.52	-53.76	0	0	53.76
	P1	0	0	0	-1	0	0	0	0	-1

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	1021.840	76.24	57.35	0	1	0	0	0	0
1 P2	d2-	594.020	42.86	35.28	1	0	0	0	0	0
1 P3	d3-	15.000	1	1	0	0	1	0	0	-1
	P3	15.000	1	1	0	0	0	0	0	-1
	P2	594.020	42.86	35.28	1	-1	0	0	0	0
	P1	1021.840	76.24	57.35	-1	1	0	0	0	-1

1st Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x1	13.403	1	0.75	0	0.01	0	0	0	0
1 P2	d2-	19.570	0	3.04	1	-0.56	0	0	0	0
1 P3	d3-	1.597	0	0.25	0	-0.01	1	0	0	-1
	P3	1.597	0	0.25	0	-0.01	0	0	0	-1
	P2	19.570	0	3.04	1	-1.56	0	0	0	0
	P1	0	0	0	-1	0	0	0	0	-1

2nd Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x1	8.560	1	0	-0.25	0.15	0	0	0	0
0 —	.x2	6.439	0	1	0.33	-0.18	0	0	0	0
1 P3	d3-	0.002	0	0	-0.08	0.03	1	0	0	-1
	P3	0.002	0	0	-0.08	0.03	0	0	0	-1
	P2	0	0	0	0	-1	0	0	0	0
	P1	0	0	0	-1	0	0	0	0	-1

GOAL PROGRAMMING SOLUTION

0th Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	541.070	98.92	76.15	0	1	0	0	0	0
1 P2	d2-	276.030	51.76	36.76	1	0	0	0	0	0
1 P3	d3-	6.000	1	1	0	0	1	0	0	-1
	P3	6.000	1	1	0	0	0	0	0	-1
	P2	276.030	51.76	36.76	1	-1	0	0	0	0
	P1	541.070	98.92	76.15	-1	1	0	0	0	-1

1st Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
1 P1	d1-	13.541	0	5.90	-1.91	1	0	0	0	0
0 —	.x1	5.333	1	0.71	0.02	0	0	0	0	0
1 P3	d3-	0.667	0	0.29	-0.02	0	1	0	0	-1
	P3	0.667	0	0.29	-0.02	0	0	0	0	-1
	P2	0	0	0	0	-1	0	0	0	0
	P1	13.541	0	5.90	-2.91	1	0	0	0	-1

2nd Iteration

			0 —	0 —	1 P1	1 P2	1 P3	0 —	0 —	1 P1
			.x1	.x2	d1-	d2-	d3-	d1+	d2+	d3+
0 —	.x2	2.296	0	1	-0.32	0.17	0	0	0	0
0 —	.x1	3.702	1	0	0.25	-0.12	0	0	0	0
1 P3	d3-	0.002	0	0	0.07	-0.05	1	0	0	-1
	P3	0.002	0	0	0.07	-0.05	0	0	0	-1
	P2	0	0	0	0	-1	0	0	0	0
	P1	0	0	0	-1	0	0	0	0	-1

Hence, the optimal solution obtained is --

x1 = 19

x2 = 15

x3 = 6

So in order to maximize occupancy, revenue the Kolhapur Municipal Transport should run 19 buses to sector 1 i.e. Bhawani Mandap and Shivaji Putla, 15 buses to sector 2 i.e. Gangavesh and Shahu Maidan and 6 buses to sector 3 i.e. Maharana Pratap Chowk and Sonya Maruti Chowk.

Similarly executing the program for three sectors we get bus allocation as follows --

i) Bhawani Mandap :- 14 buses

ii) Shivaji Putla :- 05 buses

iii) Gangavesh :- 09 buses

iv) Shahu Maidan :- 06 buses

v) Maharana Pratap Chowk :- 04 buses

vi) Sonya Maruti Chowk :- 02 buses

5.5 Analysis :-

After feeding the data as on 1st April, 1990 of Kolhapur Municipal Transport to the computer and after running the program for the solution by Goal Programming it is found that the total available buses which were forty in number should be distributed to the three sectors as follows --

i)	Bhawani Mandap and Shivaji Putla	:- 19 buses
ii)	Gangavesh and Shahu Maidan	:- 15 buses
iii)	Maharana Pratap Chowk and Sonya Maruti Chowk	:- 06 buses
	Total	:- 40 buses

Further allocation/ distribution of buses within the sector, for each Control Point is obtained by running the Goal Program again for the data available separately for each Control Point and the buses allocated by goal program for consolidate/ combined data on the basis of route length. Thus, the program was run again for three times for each sector and the distribution of buses for each Control Point obtained is as follows --

i)	Bhawani Mandap	:- 13 buses
ii)	Shivaji Putla	:- 06 buses
iii)	Gangavesh	:- 09 buses
iv)	Shahu Maidan	:- 06 buses
v)	Maharana Pratap Chowk	:- 04 buses
vi)	Sonya Maruti Chowk	:- 02 buses
	Total	:- 40 buses

where as the present allocation of buses followed by Kolhapur Municipal Transport is as follows --

i)	Bhawani Mandap	:- 12 buses
ii)	Shivaji Putla	:- Ø4 buses
iii)	Gangavesh	:- Ø9 buses
iv)	Shahu Maidan	:- Ø7 buses
v)	Maharana Pratap Chowk	:- Ø5 buses
vi)	Sonya Maruti Chowk	:- Ø3 buses
	Total	:- 4Ø buses

The comparative statement for the present allocation and the result provided by Goal Programming is as follows --

Control Point	Present Allocation of buses	Allocation by Goal Programming	Present Revenue Per Km.	Expected Revenue Per Km.
Bhawani Mandap	12	13	89.76	97.24
Shivaji Putla	Ø4	Ø6	27.ØØ	4Ø.5Ø
Gangavesh	Ø9	Ø9	73.62	73.62
Shahu Maidan	Ø7	Ø6	47.74	4Ø.92
Maharana Pratap Chowk	Ø5	Ø4	37.55	3Ø.Ø4
Sonya Maruti Chowk	Ø3	Ø2	18.Ø6	12.Ø4
Total :-	4Ø	4Ø	293.73	294.36

Thus, by Goal Programming we may achive a profit of Ø.63 paise per kilometer.

The comparative statement for the present data, for first priority to Revenue and next priority to Occupancy is as follows --

Control Point	Present Allocation of buses	Allocation by Goal Programming	Present Revenue Per Km.	Expected Revenue Per Km.
Bhawani Mandap	12	14	89.76	1Ø4.72
Shivaji Putla	Ø4	Ø5	27.ØØ	33.75
Gangavesh	Ø9	Ø9	73.62	73.62
Shahu Maidan	Ø7	Ø6	47.74	4Ø.92
Maharana Pratap Chowk	Ø5	Ø4	37.55	3Ø.Ø4
Sonya Maruti Chowk	Ø3	Ø2	18.Ø6	12.Ø4
Total :-	4Ø	4Ø	293.73	295.Ø9

Thus, by Goal Programming we may achive a profit of 1.36 paise per kilometer.

Thus Kolhapur Municipal Transport should redistribute the buses as per the above schedule which in tern provides good service and good return in terms of revenue earned.