

Problem(19) --> Data file name : DB_01_KingNakornchai(1982)_5x7.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 2, 3, 5 }
Part[ 2] = { 1, 4 }
Part[ 3] = { 2, 3 }
Part[ 4] = { 1, 4 }
Part[ 5] = { 1, 5 }
Part[ 6] = { 1, 3, 4 }
Part[ 7] = { 3, 5 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0
      0 0 0 0 0
      1 2 3 4 5
      < Machines >
      0 0 0 0 0
      0 0 0 0 0
      1 4 2 3 5
< Parts >
===== * * * * *
( 1) 2 * 1 1 *
( 2) 4 * 1 1 *
( 3) 5 * 1 1 *
( 4) 6 * 1 1 1 *
===== * = = = = *
( 5) 1 * 1 1 1 *
( 6) 3 * 1 1 *
( 7) 7 * 1 1 *
===== * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 4 }
Machine Cell[ 2] = { 2, 3, 5 }
=====
Part Family[ 1] = { 2, 4, 5, 6 }
Part Family[ 2] = { 1, 3, 7 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 5
No. of part types = 7
No. of cells = 2
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 16
Matrix density = 0.457
Total no. of within-block 1's = 14
No. of exceptional elements (EEs) = 2
No. of voids = 3
Sum of EEs and voids = 5
Group Capability Index (GCI) = 87.50 %
grouping efficiency (GE) = 85.62 %
Grouping efficacy (GF) = 73.68 %
Machine utilization (MU) = 82.35 %
No. of redundant machines (RMs) = 0
=====
```

Problem(20) --> Data file name : DB_02_KusiakCho(1992)_6x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 2, 5 }
Part[ 2] = { 1, 2 }
Part[ 3] = { 2, 3, 5 }
Part[ 4] = { 1, 4, 6 }
Part[ 5] = { 2, 5 }
Part[ 6] = { 2, 3, 5 }
Part[ 7] = { 1, 2, 4, 6 }
Part[ 8] = { 2, 3, 5 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0
      0 0 0 0 0 0
      1 2 3 4 5 6
      < Machines >
      0 0 0 0 0 0
      0 0 0 0 0 0
      1 4 6 2 3 5
< Parts >
=====
* * * * *
( 1) 2 * 1 1 *
( 2) 4 * 1 1 1 *
( 3) 7 * 1 1 1 1 *
=====
* = = = =
( 4) 1 * 1 1 *
( 5) 3 * 1 1 1 *
( 6) 5 * 1 1 *
( 7) 6 * 1 1 1 *
( 8) 8 * 1 1 1 *
=====
* * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 4, 6 }
Machine Cell[ 2] = { 2, 3, 5 }
=====
Part Family[ 1] = { 2, 4, 7 }
Part Family[ 2] = { 1, 3, 5, 6, 8 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 6
No. of part types = 8
No. of cells = 2
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 22
Matrix density = 0.458
Total no. of within-block 1's = 20
No. of exceptional elements (EEs) = 2
No. of voids = 4
Sum of EEs and voids = 6
Group Capability Index (GCI) = 90.91 %
grouping efficiency (GE) = 87.50 %
Grouping efficacy (GF) = 76.92 %
Machine utilization (MU) = 83.33 %
No. of redundant machines (RMs) = 0
=====
```

Problem(21) --> Data file name : DB_03_KusiakChow(1987)_7x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====  
Part[ 1] = { 2, 4, 6 }  
Part[ 2] = { 1 }  
Part[ 3] = { 1, 4, 7 }  
Part[ 4] = { 6, 7 }  
Part[ 5] = { 2, 5 }  
Part[ 6] = { 4, 7 }  
Part[ 7] = { 1, 7 }  
Part[ 8] = { 5, 6 }  
Part[ 9] = { 6, 7 }  
Part[10] = { 3, 6 }  
Part[11] = { 2, 3 }  
=====
```

< Block Diagonal Solution Matrix >

```
      < Locations >  
      0 0 0 0 0 0 0  
      0 0 0 0 0 0 0  
      1 2 3 4 5 6 7  
      < Machines >  
      0 0 0 0 0 0 0  
      0 0 0 0 0 0 0  
      1 4 7 3 6 2 5  
< Parts >  
===== * * * * * * * * *  
( 1) 1 * 1 1 1 *  
( 2) 2 * 1 * * *  
( 3) 3 * 1 1 1 *  
( 4) 6 * 1 1 *  
( 5) 7 * 1 1 *  
===== * = = = = = *  
( 6) 4 * 1 1 *  
( 7) 8 * 1 1 *  
( 8) 9 * 1 1 *  
( 9) 10 * 1 1 *  
===== * = = = = = *  
(10) 5 * 1 1 *  
(11) 11 * 1 1 *  
===== * * * * * * * * *
```

< Machine cells and Part families >

```
=====  
Machine Cell[ 1] = { 1, 4, 7 }  
Machine Cell[ 2] = { 3, 6 }  
Machine Cell[ 3] = { 2, 5 }  
=====  
Part Family[ 1] = { 1, 2, 3, 6, 7 }  
Part Family[ 2] = { 4, 8, 9, 10 }  
Part Family[ 3] = { 5, 11 }  
=====
```

< Summary of the performance measures >

```
=====  
No. of machines = 7  
No. of part types = 11  
No. of cells = 3  
Machine cell size = 3  
Total no. of 1's in the original MPIM : |A| = 23  
Matrix density = 0.299  
Total no. of within-block 1's = 17  
No. of exceptional elements (EEs) = 6  
No. of voids = 10  
Sum of EEs and voids = 16  
Group Capability Index (GCI) = 73.91 %  
grouping efficiency (GE) = 75.48 %  
Grouping efficacy (GF) = 51.52 %  
Machine utilization (MU) = 62.96 %  
No. of redundant machines (RMs) = 0  
=====
```

Problem(22) --> Data file name : DB_04_Boctor(1991)_7x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 3 }
Part[ 2] = { 1, 2 }
Part[ 3] = { 3, 4, 5 }
Part[ 4] = { 5, 6 }
Part[ 5] = { 6, 7 }
Part[ 6] = { 1, 2 }
Part[ 7] = { 3, 4 }
Part[ 8] = { 7 }
Part[ 9] = { 2 }
Part[10] = { 6, 7 }
Part[11] = { 3, 5 }
=====
```

< Block Diagonal Solution Matrix >

```

    < Locations >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
    < Machines >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
< Parts >
===== * * * * *
( 1) 2 * 1 1 *
( 2) 6 * 1 1 *
( 3) 9 * 1 *
===== * = = = = *
( 4) 1 * 1 1 *
( 5) 3 * 1 1 1 *
( 6) 7 * 1 1 *
( 7) 11 * 1 1 *
===== * = = = = *
( 8) 4 * 1 1 *
( 9) 5 * 1 1 *
(10) 8 * 1 *
(11) 10 * 1 1 *
===== * * * * *
=====
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 2 }
Machine Cell[ 2] = { 3, 4, 5 }
Machine Cell[ 3] = { 6, 7 }
=====
Part Family[ 1] = { 2, 6, 9 }
Part Family[ 2] = { 1, 3, 7, 11 }
Part Family[ 3] = { 4, 5, 8, 10 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 7
No. of part types = 11
No. of cells = 3
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 21
Matrix density = 0.273
Total no. of within-block 1's = 19
No. of exceptional elements (EEs) = 2
No. of voids = 7
Sum of EEs and voids = 9
Group Capability Index (GCI) = 90.48 %
grouping efficiency (GE) = 84.58 %
Grouping efficacy (GF) = 67.86 %
Machine utilization (MU) = 73.08 %
No. of redundant machines (RMs) = 0
=====
```

Problem(23) --> Data file name : DB_05_SeifoddiniWolfe(1986)_8x12.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 2 }
Part[ 2] = { 1 }
Part[ 3] = { 1, 2, 3 }
Part[ 4] = { 1, 2, 3 }
Part[ 5] = { 2, 3 }
Part[ 6] = { 2, 3, 4 }
Part[ 7] = { 2, 3, 4, 5, 6 }
Part[ 8] = { 3, 4, 5, 6 }
Part[ 9] = { 3, 4, 5, 6 }
Part[10] = { 2, 4, 5 }
Part[11] = { 6, 7, 8 }
Part[12] = { 7, 8 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
      < Machines >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
< Parts >
===== * * * * *
( 1) 1 * 1 1 *
( 2) 2 * 1 *
( 3) 3 * 1 1 1 *
( 4) 4 * 1 1 1 *
( 5) 5 * 1 1 *
( 6) 6 * 1 1 1 *
===== * = = = = *
( 7) 7 * 1 1 1 1 1 *
( 8) 8 * 1 1 1 1 *
( 9) 9 * 1 1 1 1 *
(10)10 * 1 1 1 *
===== * = = = = *
(11)11 * 1 1 1 *
(12)12 * 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 2, 3 }
Machine Cell[ 2] = { 4, 5, 6 }
Machine Cell[ 3] = { 7, 8 }
=====
Part Family[ 1] = { 1, 2, 3, 4, 5, 6 }
Part Family[ 2] = { 7, 8, 9, 10 }
Part Family[ 3] = { 11, 12 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 8
No. of part types              = 12
No. of cells                   = 3
Machine cell size              = 4
Total no. of 1's in the original MPIM : |A| = 35
Matrix density                 = 0.365
Total no. of within-block 1's = 28
No. of exceptional elements (EEs) = 7
No. of voids                   = 6
Sum of EEs and voids          = 13
Group Capability Index (GCI)   = 80.00 %
grouping efficiency (GE)       = 85.53 %
Grouping efficacy (GF)         = 68.29 %
Machine utilization (MU)       = 82.35 %

```

No. of redundant machines (RMs) = 0
=====

Problem(24) --> Data file name : DB_06_ChandraRaja(1989a)_8x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 5, 6 }
Part[ 2] = { 1, 3 }
Part[ 3] = { 1, 2, 4, 7, 8 }
Part[ 4] = { 2, 4, 7, 8 }
Part[ 5] = { 5, 6 }
Part[ 6] = { 2, 4, 5, 7, 8 }
Part[ 7] = { 2, 4, 7, 8 }
Part[ 8] = { 1, 3 }
Part[ 9] = { 1, 3, 6 }
Part[10] = { 4, 5, 6 }
Part[11] = { 1, 3, 7 }
Part[12] = { 5, 6, 7 }
Part[13] = { 1, 3 }
Part[14] = { 1, 2, 3 }
Part[15] = { 5, 6 }
Part[16] = { 1, 3 }
Part[17] = { 1, 3, 5 }
Part[18] = { 2, 4, 7, 8 }
Part[19] = { 1, 3 }
Part[20] = { 2, 4, 6, 7, 8 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
      < Machines >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 3 2 4 7 8 5 6
< Parts >
===== * * * * *
( 1) 2 * 1 1 *
( 2) 8 * 1 1 *
( 3) 9 * 1 1 1 *
( 4) 11 * 1 1 1 *
( 5) 13 * 1 1 1 *
( 6) 14 * 1 1 1 *
( 7) 16 * 1 1 1 *
( 8) 17 * 1 1 1 *
( 9) 19 * 1 1 1 *
===== * = = = = *
(10) 3 * 1 1 1 1 1 *
(11) 4 * 1 1 1 1 1 *
(12) 6 * 1 1 1 1 1 *
(13) 7 * 1 1 1 1 1 *
(14) 18 * 1 1 1 1 1 *
(15) 20 * 1 1 1 1 1 *
===== * = = = = *
(16) 1 * 1 1 *
(17) 5 * 1 1 *
(18) 10 * 1 1 *
(19) 12 * 1 1 *
(20) 15 * 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 3 }
Machine Cell[ 2] = { 2, 4, 7, 8 }
Machine Cell[ 3] = { 5, 6 }
=====
Part Family[ 1] = { 2, 8, 9, 11, 13, 14, 16, 17, 19 }
Part Family[ 2] = { 3, 4, 6, 7, 18, 20 }
Part Family[ 3] = { 1, 5, 10, 12, 15 }
=====

```

< Summary of the performance measures >

```
=====
No. of machines                = 8
No. of part types              = 20
No. of cells                   = 3
Machine cell size              = 4
Total no. of 1's in the original MPIM : |A| = 61
Matrix density                 = 0.381
Total no. of within-block 1's = 52
No. of exceptional elements (EEs) = 9
No. of voids                   = 0
Sum of EEs and voids          = 9
Group Capability Index (GCI)   = 85.25 %
grouping efficiency (GE)       = 95.83 %
Grouping efficacy (GF)        = 85.25 %
Machine utilization (MU)       = 100.00%
No. of redundant machines (RMs) = 0
=====
```


Problem(25) --> Data file name : DB_07_ChandraRaja(1989b)_8x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 5, 6, 8 }
Part[ 2] = { 2, 5, 6, 8 }
Part[ 3] = { 1, 2, 4, 5, 8 }
Part[ 4] = { 1, 2, 4, 8 }
Part[ 5] = { 3, 6, 7, 8 }
Part[ 6] = { 2, 3, 5, 7 }
Part[ 7] = { 2, 3, 4, 6, 7 }
Part[ 8] = { 3, 4, 6, 7, 8 }
Part[ 9] = { 1, 2, 4, 8 }
Part[10] = { 1, 4, 5, 6, 8 }
Part[11] = { 2, 3, 6, 7 }
Part[12] = { 3, 5, 6, 7 }
Part[13] = { 3, 4, 5, 7, 8 }
Part[14] = { 1, 4, 6, 8 }
Part[15] = { 1, 4, 5, 6 }
Part[16] = { 1, 3, 5, 6, 7, 8 }
Part[17] = { 3, 4, 5, 7, 8 }
Part[18] = { 1, 2, 4, 6 }
Part[19] = { 1, 3, 4, 5, 6, 7 }
Part[20] = { 2, 3, 4, 5, 7 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
      < Machines >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 4 3 5 6 7 8
< Parts >
===== * * * * *
( 1) 3 * 1 1 1 1 *
( 2) 4 * 1 1 1 1 *
( 3) 9 * 1 1 1 1 *
( 4) 18 * 1 1 1 1 *
===== * = = = = *
( 5) 1 * 1 1 1 1 *
( 6) 2 * 1 1 1 1 *
( 7) 5 * 1 1 1 1 *
( 8) 6 * 1 1 1 1 *
( 9) 7 * 1 1 1 1 *
(10) 8 * 1 1 1 1 *
(11) 10 * 1 1 1 1 *
(12) 11 * 1 1 1 1 *
(13) 12 * 1 1 1 1 *
(14) 13 * 1 1 1 1 *
(15) 14 * 1 1 1 1 *
(16) 15 * 1 1 1 1 *
(17) 16 * 1 1 1 1 *
(18) 17 * 1 1 1 1 *
(19) 19 * 1 1 1 1 *
(20) 20 * 1 1 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 2, 4 }
Machine Cell[ 2] = { 3, 5, 6, 7, 8 }
=====
Part Family[ 1] = { 3, 4, 9, 18 }
Part Family[ 2] = { 1, 2, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 8

```

No. of part types	= 20
No. of cells	= 2
Machine cell size	= 5
Total no. of 1's in the original MPIM : A	= 91
Matrix density	= 0.569
Total no. of within-block 1's	= 66
No. of exceptional elements (EES)	= 25
No. of voids	= 26
Sum of EES and voids	= 51
Group Capability Index (GCI)	= 72.53 %
grouping efficiency (GE)	= 67.49 %
Grouping efficacy (GF)	= 56.41 %
Machine utilization (MU)	= 71.74 %
No. of redundant machines (RMs)	= 0

=====

Problem(26) --> Data file name : DB_08_Carrie(1973)_20x35.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 3, 7, 8, 17 }
Part[ 2] = { 2, 4, 13, 14, 18 }
Part[ 3] = { 1, 3, 7, 8, 17 }
Part[ 4] = { 11, 12, 15, 16, 19 }
Part[ 5] = { 3, 7, 8, 17 }
Part[ 6] = { 11, 12, 15, 16 }
Part[ 7] = { 2, 4, 14 }
Part[ 8] = { 5, 6, 9, 10, 20 }
Part[ 9] = { 11, 12, 15, 16, 19 }
Part[10] = { 2, 14, 18 }
Part[11] = { 11, 12, 15, 16, 19 }
Part[12] = { 2, 4, 13, 14, 18 }
Part[13] = { 2, 4, 13, 14, 18 }
Part[14] = { 5, 6, 9, 10, 20 }
Part[15] = { 3, 7, 8, 17 }
Part[16] = { 5, 6, 10 }
Part[17] = { 3, 7, 8, 17 }
Part[18] = { 2, 14, 18 }
Part[19] = { 6, 9, 10, 20 }
Part[20] = { 1, 7, 8 }
Part[21] = { 11, 12, 15, 16, 19 }
Part[22] = { 6, 9, 10 }
Part[23] = { 1, 7, 8, 17 }
Part[24] = { 2, 4, 13, 14, 18 }
Part[25] = { 1, 8, 17 }
Part[26] = { 6, 9, 10, 20 }
Part[27] = { 2, 4, 14 }
Part[28] = { 11, 15, 16, 19 }
Part[29] = { 1, 3, 8, 17 }
Part[30] = { 11, 15, 16, 19 }
Part[31] = { 2, 3, 14, 18 }
Part[32] = { 11, 16, 19 }
Part[33] = { 12 }
Part[34] = { 5, 6 }
Part[35] = { 11 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 1 1 1 0 0 0 0 0 1 0 2 1 1 1 1 1 0 0 1
      2 4 3 4 8 1 3 7 8 7 5 0 1 2 5 6 9 6 9 0
< Parts >
=====
( 1) 2 * 1 1 1 1 1 *
( 2) 7 * 1 1 1 *
( 3) 10 * 1 1 1 *
( 4) 12 * 1 1 1 1 1 *
( 5) 13 * 1 1 1 1 1 *
( 6) 18 * 1 1 1 1 *
( 7) 24 * 1 1 1 1 1 *
( 8) 27 * 1 1 1 *
( 9) 31 * 1 1 1 1 1 *
=====
(10) 1 * 1 1 1 1 1 *
(11) 3 * 1 1 1 1 1 *
(12) 5 * 1 1 1 1 *
(13) 15 * 1 1 1 1 *
(14) 17 * 1 1 1 1 *
(15) 20 * 1 1 1 *
(16) 23 * 1 1 1 1 *
(17) 25 * 1 1 1 *
(18) 29 * 1 1 1 1 *
=====

```

```

===== * = = = = = = = = = = = = = = = = = = = = = *
( 19) 4 * 1 1 1 1 1 *
( 20) 6 * 1 1 1 1 *
( 21) 9 * 1 1 1 1 1 *
( 22) 11 * 1 1 1 1 1 *
( 23) 21 * 1 1 1 1 1 *
( 24) 28 * 1 1 1 1 *
( 25) 30 * 1 1 1 1 *
( 26) 32 * 1 1 1 *
( 27) 33 * 1 *
( 28) 35 * 1 *
===== * = = = = = = = = = = = = = = = = = = = = = *
( 29) 8 * 1 1 1 1 1 *
( 30) 14 * 1 1 1 1 1 *
( 31) 16 * 1 1 1 *
( 32) 19 * 1 1 1 *
( 33) 22 * 1 1 1 *
( 34) 26 * 1 1 1 *
( 35) 34 * 1 *
===== * * * * * * * * * * * * * * * * * * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 2, 4, 13, 14, 18 }
Machine Cell[ 2] = { 1, 3, 7, 8, 17 }
Machine Cell[ 3] = { 5, 20 } --> Residual cell
Machine Cell[ 4] = { 11, 12, 15, 16, 19 }
Machine Cell[ 5] = { 6, 9, 10 }
=====
Part Family[ 1] = { 2, 7, 10, 12, 13, 18, 24, 27, 31 }
Part Family[ 2] = { 1, 3, 5, 15, 17, 20, 23, 25, 29 }
Part Family[ 3] --> Empty Part family
Part Family[ 4] = { 4, 6, 9, 11, 21, 28, 30, 32, 33, 35 }
Part Family[ 5] = { 8, 14, 16, 19, 22, 26, 34 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 20
No. of part types = 35
No. of cells = 5
Machine cell size = 5
Total no. of 1's in the original MPIM : |A| = 135
Matrix density = 0.193
Total no. of within-block 1's = 126
No. of exceptional elements (EES) = 9
No. of voids = 35
Sum of EES and voids = 44
Group Capability Index (GCI) = 93.33 %
grouping efficiency (GE) = 88.30 %
Grouping efficacy (GF) = 74.12 %
Machine utilization (MU) = 78.26 %
No. of redundant machines (RMs) = 2
=====

```

Problem(27) --> Data file name : DB_09_ChandraRaja_2_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 13, 21, 22 }
Part[ 2] = { 3, 20, 24 }
Part[ 3] = { 7, 14, 23, 24 }
Part[ 4] = { 6, 8, 12, 15, 18 }
Part[ 5] = { 5, 6, 8, 12, 15, 18 }
Part[ 6] = { 9, 10, 17 }
Part[ 7] = { 9, 10, 17 }
Part[ 8] = { 4, 16 }
Part[ 9] = { 1, 13, 21, 22 }
Part[10] = { 2, 5, 11, 19, 21 }
Part[11] = { 3, 20 }
Part[12] = { 3, 20 }
Part[13] = { 2, 11, 19 }
Part[14] = { 2, 5, 11, 19 }
Part[15] = { 3, 20 }
Part[16] = { 1, 13, 21, 22 }
Part[17] = { 1, 13, 22 }
Part[18] = { 6, 8, 12, 15, 18 }
Part[19] = { 4, 16 }
Part[20] = { 10, 12, 17 }
Part[21] = { 4, 16 }
Part[22] = { 2, 5, 11, 19 }
Part[23] = { 3, 20 }
Part[24] = { 3, 12, 20 }
Part[25] = { 7, 14, 23 }
Part[26] = { 6, 8, 10, 15, 18 }
Part[27] = { 6, 8, 12, 15, 18 }
Part[28] = { 4 }
Part[29] = { 9, 17 }
Part[30] = { 6, 8, 12, 18 }
Part[31] = { 3, 17, 20 }
Part[32] = { 7, 14, 16, 23, 24 }
Part[33] = { 1, 2, 13, 21, 22 }
Part[34] = { 3, 20 }
Part[35] = { 5, 11, 19 }
Part[36] = { 5, 11, 19 }
Part[37] = { 15, 16 }
Part[38] = { 4, 16 }
Part[39] = { 4, 16 }
Part[40] = { 9, 10, 17 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 2 0 1 0 0 1 1 0 0 1 1 1 0 1 2 2 0 1 1 0 1 2 2
      3 0 4 6 2 5 1 9 6 8 2 5 8 1 3 1 2 9 0 7 7 4 3 4
< Parts >
===== * * * * *
( 1) 2 * 1 1 * * * * *
( 2) 11 * 1 1 * * * * *
( 3) 12 * 1 1 * * * * *
( 4) 15 * 1 1 * * * * *
( 5) 23 * 1 1 * * * * *
( 6) 24 * 1 1 * 1 * * * * *
( 7) 31 * 1 1 * * 1 * * * *
( 8) 34 * 1 1 * * * 1 * * * *
===== * = = = = =
( 9) 8 * 1 1 * * * * *
(10) 19 * 1 1 * * * * *
(11) 21 * 1 1 * * * * *
(12) 28 * 1 * * * * *
(13) 37 * 1 * 1 * * * * *
(14) 38 * 1 1 * * * * *

```

```

( 15) 39 *      1 1
=====
( 16) 10 *      1 1 1 1      1
( 17) 13 *      1 1 1
( 18) 14 *      1 1 1 1
( 19) 22 *      1 1 1 1
( 20) 35 *      1 1 1
( 21) 36 *      1 1 1
=====
( 22) 4  *      1 1 1 1 1
( 23) 5  *      1 1 1 1 1
( 24) 18 *      1 1 1 1 1
( 25) 26 *      1 1 1 1      1
( 26) 27 *      1 1 1 1 1
( 27) 30 *      1 1 1 1
=====
( 28) 1  *      1 1 1 1
( 29) 9  *      1 1 1 1
( 30) 16 *      1 1 1 1
( 31) 17 *      1 1 1
( 32) 33 *      1 1 1 1
=====
( 33) 6  *      1 1 1
( 34) 7  *      1 1 1
( 35) 20 *      1 1
( 36) 29 *      1 1
( 37) 40 *      1 1 1
=====
( 38) 3  *      1 1 1 1
( 39) 25 *      1 1 1
( 40) 32 *      1 1 1 1
=====
* * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 3, 20 }
Machine Cell[ 2] = { 4, 16 }
Machine Cell[ 3] = { 2, 5, 11, 19 }
Machine Cell[ 4] = { 6, 8, 12, 15, 18 }
Machine Cell[ 5] = { 1, 13, 21, 22 }
Machine Cell[ 6] = { 9, 10, 17 }
Machine Cell[ 7] = { 7, 14, 23, 24 }
=====
Part Family[ 1] = { 2, 11, 12, 15, 23, 24, 31, 34 }
Part Family[ 2] = { 8, 19, 21, 28, 37, 38, 39 }
Part Family[ 3] = { 10, 13, 14, 22, 35, 36 }
Part Family[ 4] = { 4, 5, 18, 26, 27, 30 }
Part Family[ 5] = { 1, 9, 16, 17, 33 }
Part Family[ 6] = { 6, 7, 20, 29, 40 }
Part Family[ 7] = { 3, 25, 32 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 24
No. of part types              = 40
No. of cells                   = 7
Machine cell size              = 5
Total no. of 1's in the original MPIM : |A| = 130
Matrix density                 = 0.135
Total no. of within-block 1's = 120
No. of exceptional elements (EEs) = 10
No. of voids                   = 11
Sum of EEs and voids          = 21
Group Capability Index (GCI)   = 92.31 %
grouping efficiency (GE)       = 95.20 %
Grouping efficacy (GF)        = 85.11 %
Machine utilization (MU)       = 91.60 %
No. of redundant machines (RMs) = 0
=====

```

Problem(28) --> Data file name : DB_10_ChandraRaja_3_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 13, 15, 21, 22 }
Part[ 2] = { 3, 20, 24 }
Part[ 3] = { 14, 23, 24 }
Part[ 4] = { 8, 12, 15, 18 }
Part[ 5] = { 5, 6, 8, 12, 15, 18 }
Part[ 6] = { 9, 10 }
Part[ 7] = { 9, 10, 17 }
Part[ 8] = { 4, 16 }
Part[ 9] = { 1, 13, 21 }
Part[10] = { 2, 5, 11, 19, 21 }
Part[11] = { 3, 20 }
Part[12] = { 3, 20 }
Part[13] = { 2, 11, 19 }
Part[14] = { 2, 5, 14, 19 }
Part[15] = { 3, 20 }
Part[16] = { 1, 13, 14, 21, 22 }
Part[17] = { 1, 13, 22 }
Part[18] = { 6, 12, 15, 18 }
Part[19] = { 1, 4, 16, 20 }
Part[20] = { 10, 12, 17 }
Part[21] = { 4, 16 }
Part[22] = { 2, 5, 11, 19 }
Part[23] = { 3, 20 }
Part[24] = { 3, 12, 20 }
Part[25] = { 7, 14, 23 }
Part[26] = { 6, 8, 10, 15, 18 }
Part[27] = { 6, 8, 12, 15, 18 }
Part[28] = { 4 }
Part[29] = { 9, 17 }
Part[30] = { 6, 8, 12, 18, 22 }
Part[31] = { 17, 20 }
Part[32] = { 7, 16, 23, 24 }
Part[33] = { 1, 2, 9, 13, 21, 22 }
Part[34] = { 3, 20 }
Part[35] = { 5, 11, 19 }
Part[36] = { 2, 5, 11, 19 }
Part[37] = { 15, 16 }
Part[38] = { 4, 6, 16 }
Part[39] = { 4, 16 }
Part[40] = { 7, 9, 17, 19 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 1 1 1 1 0 2 0 0 1 1 0 1 2 2 0 1 2 2 0 1 0 1 1
      6 8 2 5 8 3 0 2 5 1 9 7 4 3 4 1 3 1 2 4 6 9 0 7
< Parts >
===== * * * * *
( 1) 4 * 1 1 1 1
( 2) 5 * 1 1 1 1 1
( 3) 18 * 1 1 1 1
( 4) 26 * 1 1 1 1
( 5) 27 * 1 1 1 1 1
( 6) 30 * 1 1 1 1
( 7) 37 * 1
===== * * * * *
( 8) 2 * 1 1
( 9) 11 * 1 1
(10) 12 * 1 1
(11) 15 * 1 1
(12) 23 * 1 1
(13) 24 * 1 1
(14) 31 * 1
=====

```

```

( 15) 34 *          1 1          *
===== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
( 16) 10 *          1 1 1 1          1          *
( 17) 13 *          1 1 1          *
( 18) 14 *          1 1 1 1          *
( 19) 22 *          1 1 1 1          *
( 20) 35 *          1 1 1          *
( 21) 36 *          1 1 1 1          *
===== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
( 22) 3  *          1 1 1          *
( 23) 25 *          1 1 1          *
( 24) 32 *          1 1 1          1          *
===== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
( 25) 1  *          1          1 1 1          *
( 26) 9  *          1 1 1          *
( 27) 16 *          1 1 1 1          *
( 28) 17 *          1 1 1          *
( 29) 33 *          1 1 1 1          1          *
===== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
( 30) 8  *          1 1          *
( 31) 19 *          1 1          *
( 32) 21 *          1 1          *
( 33) 28 *          1          *
( 34) 38 * 1          1 1          *
( 35) 39 *          1 1          *
===== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
( 36) 6  *          1 1          *
( 37) 7  *          1 1 1          *
( 38) 20 *          1 1          *
( 39) 29 *          1 1          *
( 40) 40 *          1 1          *
===== * * * * * * * * * * * * * * * * * * * * * * * * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 6, 8, 12, 15, 18 }
Machine Cell[ 2] = { 3, 20 }
Machine Cell[ 3] = { 2, 5, 11, 19 }
Machine Cell[ 4] = { 7, 14, 23, 24 }
Machine Cell[ 5] = { 1, 13, 21, 22 }
Machine Cell[ 6] = { 4, 16 }
Machine Cell[ 7] = { 9, 10, 17 }
=====
Part Family[ 1] = { 4, 5, 18, 26, 27, 30, 37 }
Part Family[ 2] = { 2, 11, 12, 15, 23, 24, 31, 34 }
Part Family[ 3] = { 10, 13, 14, 22, 35, 36 }
Part Family[ 4] = { 3, 25, 32 }
Part Family[ 5] = { 1, 9, 16, 17, 33 }
Part Family[ 6] = { 8, 19, 21, 28, 38, 39 }
Part Family[ 7] = { 6, 7, 20, 29, 40 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 24
No. of part types              = 40
No. of cells                   = 7
Machine cell size              = 5
Total no. of 1's in the original MPIM : |A| = 131
Matrix density                 = 0.136
Total no. of within-block 1's = 111
No. of exceptional elements (EEs) = 20
No. of voids                   = 23
Sum of EEs and voids          = 43
Group Capability Index (GCI)   = 84.73 %
grouping efficiency (GE)       = 90.21 %
Grouping efficacy (GF)        = 72.08 %
Machine utilization (MU)       = 82.84 %
No. of redundant machines (RMs) = 0
=====

```


Problem(29) --> Data file name : DB_11_McCormick(1972)_37x53.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 4, 6, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 23,
26, 27, 30, 31, 32, 36 }
Part[ 2] = { 3, 4, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19,
20, 21, 23, 25, 26, 27, 28, 29, 30, 31, 33, 35, 36 }
Part[ 3] = { 4, 6, 8, 10, 11, 14, 15, 17, 18, 19, 20, 21, 23, 26, 30,
31, 33, 35 }
Part[ 4] = { 2, 3, 5, 6, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23,
26, 31, 33, 34, 35, 37 }
Part[ 5] = { 4, 8, 10, 11, 14, 17, 18, 19, 20, 21, 23, 26, 30, 31 }
Part[ 6] = { 3, 4, 6, 7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20,
21, 23, 25, 26, 28, 29, 30, 31, 33 }
Part[ 7] = { 5, 8, 11, 14, 15, 17, 18, 19, 20, 21, 23, 26, 28, 31, 33,
35 }
Part[ 8] = { 4, 8, 10, 11, 14, 15, 17, 18, 19, 20, 21, 23, 26, 30, 31 }
Part[ 9] = { 3, 4, 8, 10, 11, 14, 15, 17, 18, 19, 20, 21, 23, 26, 30,
31 }
Part[10] = { 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31, 33, 35 }
Part[11] = { 2, 5, 8, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26,
31, 33, 35, 37 }
Part[12] = { 8, 10, 11, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31, 33 }
Part[13] = { 5, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31, 33,
35 }
Part[14] = { 3, 4, 6, 7, 8, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21,
23, 25, 26, 28, 29, 31, 33, 35 }
Part[15] = { 5, 8, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26, 31,
33, 35, 37 }
Part[16] = { 3, 4, 6, 7, 8, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21,
23, 25, 26, 28, 29, 31, 33, 35 }
Part[17] = { 2, 3, 5, 6, 7, 8, 11, 13, 14, 15, 16, 17, 18, 19, 20,
21, 23, 26, 31, 33, 34, 35, 37 }
Part[18] = { 2, 3, 4, 5, 6, 7, 8, 11, 13, 14, 15, 16, 17, 18, 19,
20, 21, 23, 25, 26, 28, 29, 31, 33, 34, 35, 37 }
Part[19] = { 5, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31, 33,
35 }
Part[20] = { 2, 3, 5, 6, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23,
26, 31, 33, 34, 35, 37 }
Part[21] = { 2, 5, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31,
33, 35, 37 }
Part[22] = { 8, 11, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31, 33, 35 }
Part[23] = { 2, 3, 5, 6, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23,
26, 31, 33, 34, 35, 37 }
Part[24] = { 4, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26,
27, 30, 31, 32, 33, 36 }
Part[25] = { 3, 4, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21,
23, 26, 27, 30, 31, 36 }
Part[26] = { 1, 3, 4, 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 22, 24,
26, 27, 28, 30, 32, 33 }
Part[27] = { 1, 3, 4, 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 22, 24,
26, 27, 30, 32 }
Part[28] = { 1, 3, 4, 6, 7, 8, 9, 10, 11, 14, 16, 17, 18, 19, 21,
22, 24, 25, 26, 27, 28, 29, 30, 32 }
Part[29] = { 1, 4, 8, 10, 11, 14, 17, 21, 22, 24, 26, 27, 28, 30, 32 }
Part[30] = { 1, 4, 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 22, 24, 26,
27, 28, 30, 32 }
Part[31] = { 1, 3, 4, 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 22, 24,
26, 27, 28, 30, 32 }
Part[32] = { 1, 3, 4, 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 22, 24,
26, 27, 28, 30, 32 }
Part[33] = { 1, 3, 4, 6, 7, 8, 9, 10, 11, 14, 16, 17, 18, 19, 21,
22, 24, 25, 26, 27, 28, 29, 32 }
Part[34] = { 1, 4, 8, 10, 11, 14, 17, 21, 22, 24, 26, 27, 28, 30, 32 }
Part[35] = { 1, 3, 4, 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 22, 24,
25, 26, 27, 28, 30, 32 }
Part[36] = { 1, 3, 4, 6, 7, 8, 9, 10, 11, 14, 16, 17, 18, 19, 21,
22, 24, 25, 26, 27, 28, 29, 30, 32 }
Part[37] = { 1, 3, 4, 7, 8, 9, 10, 11, 14, 16, 17, 18, 19, 21, 22,
24, 25, 26, 27, 28, 30, 32 }
Part[38] = { 1, 3, 4, 6, 7, 8, 9, 10, 11, 14, 16, 17, 18, 19, 21,
22, 24, 25, 26, 27, 28, 29, 32 }
Part[39] = { 1, 4, 8, 10, 11, 14, 17, 21, 22, 24, 26, 27, 28, 30, 32 }
Part[40] = { 4, 10, 11, 12, 14, 17, 21, 24, 26, 27, 28, 30, 31, 32 }
Part[41] = { 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31, 33, 37 }
Part[42] = { 2, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 23, 26, 31, 33,
35, 37 }
```



```

( 49) 49 *          1      1          1 1 1 1 1 1          1 1 1 1 1 1 1 1 *
( 50) 50 *          1      1          1 1 1 1 1 1          1 1 1 1 1 1 1 1 *
( 51) 51 *          1          1 1 1 1 1 1          1 1 1 1 1 1 1 1 *
( 52) 52 *          1          1 1 1 1 1 1          1 1 1 1 1 1 1 1 *
( 53) 53 *          1          1 1 1 1 1 1          1 1 1 1 1 1 1 1 *
===== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 2, 5, 6, 7, 9, 12, 13, 16, 22, 24, 25, 29, 34, 35, 36, 37 } -->
Residual cell
Machine Cell[ 2] = { 3, 4, 8, 10, 11, 14, 15, 17, 18, 19, 20, 21, 23, 26, 27, 28, 30, 31,
32, 33 }
=====
Part Family[ 1] --> Empty Part family
Part Family[ 2] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43,
44, 45, 46, 47, 48, 49, 50, 51, 52, 53 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 37
No. of part types              = 53
No. of cells                   = 2
Machine cell size              = 20
Total no. of 1's in the original MPIM : |A| = 977
Matrix density                 = 0.498
Total no. of within-block 1's = 763
No. of exceptional elements (EEs) = 214
No. of voids                   = 297
Sum of EEs and voids          = 511
Group Capability Index (GCI)   = 78.10 %
grouping efficiency (GE)       = 74.11 %
Grouping efficacy (GF)         = 59.89 %
Machine utilization (MU)       = 71.98 %
No. of redundant machines (RMs) = 17
=====

```

Problem(30) --> Data file name : DB_12_McAuley(1972)_12x10.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 2, 3, 4, 11, 12 }
Part[ 2] = { 1, 2, 3, 4, 11, 12 }
Part[ 3] = { 1, 2, 3 }
Part[ 4] = { 1, 2, 7 }
Part[ 5] = { 5, 6, 7, 11, 12 }
Part[ 6] = { 5, 6, 7, 11, 12 }
Part[ 7] = { 5, 6 }
Part[ 8] = { 8, 9, 10 }
Part[ 9] = { 8, 9, 10 }
Part[10] = { 8, 9 }
=====
```

< Block Diagonal Solution Matrix >

```

  < Locations >
    0 0 0 0 0 0 0 0 0 0 0 0
    0 0 0 0 0 0 0 0 0 1 1 1
    1 2 3 4 5 6 7 8 9 0 1 2
  < Machines >
    0 0 0 0 0 0 0 0 0 0 0 0
    0 0 0 0 1 1 0 0 0 0 0 1
    1 2 3 4 1 2 5 6 7 8 9 0
< Parts >
=====
( 1) 1 * 1 1 1 1 1 1
( 2) 2 * 1 1 1 1 1 1
( 3) 3 * 1 1 1
( 4) 4 * 1 1
=====
( 5) 5 * 1 1 1 1 1
( 6) 6 * 1 1 1 1
( 7) 7 * 1 1
=====
( 8) 8 * 1 1 1
( 9) 9 * 1 1 1
(10)10 * 1 1
=====
* * * * *
=====
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 2, 3, 4, 11, 12 }
Machine Cell[ 2] = { 5, 6, 7 }
Machine Cell[ 3] = { 8, 9, 10 }
=====
```

```
Part Family[ 1] = { 1, 2, 3, 4 }
Part Family[ 2] = { 5, 6, 7 }
Part Family[ 3] = { 8, 9, 10 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines                = 12
No. of part types              = 10
No. of cells                   = 3
Machine cell size              = 6
Total no. of 1's in the original MPIM : |A| = 38
Matrix density                 = 0.317
Total no. of within-block 1's = 33
No. of exceptional elements (EEs) = 5
No. of voids                   = 9
Sum of EEs and voids          = 14
Group Capability Index (GCI)   = 86.84 %
grouping efficiency (GE)       = 86.08 %
Grouping efficacy (GF)         = 70.21 %
Machine utilization (MU)       = 78.57 %
No. of redundant machines (RMs) = 0
=====
```

Problem(31) --> Data file name : DB_13_King(1980)_14x24.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 4, 5, 7 }
Part[ 2] = { 4, 5, 7 }
Part[ 3] = { 2, 3, 10, 11 }
Part[ 4] = { 2, 3, 11 }
Part[ 5] = { 8, 9 }
Part[ 6] = { 1, 13 }
Part[ 7] = { 1, 7, 12, 13 }
Part[ 8] = { 12, 13 }
Part[ 9] = { 6, 8, 9, 14 }
Part[10] = { 6, 8 }
Part[11] = { 6, 14 }
Part[12] = { 6, 8, 9 }
Part[13] = { 9, 14 }
Part[14] = { 6, 8 }
Part[15] = { 6, 8, 9, 14 }
Part[16] = { 6, 8 }
Part[17] = { 4, 5 }
Part[18] = { 13 }
Part[19] = { 4 }
Part[20] = { 4, 5 }
Part[21] = { 3, 11 }
Part[22] = { 6, 8 }
Part[23] = { 4, 5, 13 }
Part[24] = { 10, 11 }
=====

```

< Block Diagonal Solution Matrix >

< Locations >

```

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 1
1 2 3 4 5 6 7 8 9 0 1 2 3 4

```

< Machines >

```

0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 1 1 0 1 1
4 5 7 6 8 9 4 2 3 0 1 1 2 3

```

< Parts >

```

=====
( 1) 1 * 1 1 1 *
( 2) 2 * 1 1 1 *
( 3) 17 * 1 1 *
( 4) 19 * 1 *
( 5) 20 * 1 1 *
( 6) 23 * 1 1 1
=====
( 7) 5 * 1 1 *
( 8) 9 * 1 1 1 1 *
( 9) 10 * 1 1 *
(10) 11 * 1 1 *
(11) 12 * 1 1 1 *
(12) 13 * 1 1 *
(13) 14 * 1 1 *
(14) 15 * 1 1 1 1 *
(15) 16 * 1 1 *
(16) 22 * 1 1 *
=====
(17) 3 * 1 1 1 1 *
(18) 4 * 1 1 1 *
(19) 21 * 1 1 *
(20) 24 * 1 1 *
=====
(21) 6 * 1 1 *
(22) 7 * 1 1 1 *
(23) 8 * 1 1 *
(24) 18 * 1 *
=====
* * * * *

```

< Machine cells and Part families >

=====

```
Machine Cell[ 1] = { 4, 5, 7 }
Machine Cell[ 2] = { 6, 8, 9, 14 }
Machine Cell[ 3] = { 2, 3, 10, 11 }
Machine Cell[ 4] = { 1, 12, 13 }
```

```
=====  
Part Family[ 1] = { 1, 2, 17, 19, 20, 23 }  
Part Family[ 2] = { 5, 9, 10, 11, 12, 13, 14, 15, 16, 22 }  
Part Family[ 3] = { 3, 4, 21, 24 }  
Part Family[ 4] = { 6, 7, 8, 18 }  
=====
```

< Summary of the performance measures >

```
=====  
No. of machines = 14  
No. of part types = 24  
No. of cells = 4  
Machine cell size = 4  
Total no. of 1's in the original MPIM : |A| = 59  
Matrix density = 0.176  
Total no. of within-block 1's = 57  
No. of exceptional elements (EES) = 2  
No. of voids = 29  
Sum of EES and voids = 31  
Group Capability Index (GCI) = 96.61 %  
grouping efficiency (GE) = 82.74 %  
Grouping efficacy (GF) = 64.77 %  
Machine utilization (MU) = 66.28 %  
No. of redundant machines (RMs) = 0  
=====
```

Problem(32) --> Data file name : DB_14_Ham(1985)_10x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 2, 4, 8 }
Part[ 2] = { 3, 6, 10 }
Part[ 3] = { 1, 4, 8 }
Part[ 4] = { 5, 9 }
Part[ 5] = { 3, 6, 7 }
Part[ 6] = { 1, 2, 4, 8 }
Part[ 7] = { 5, 9, 10 }
Part[ 8] = { 1, 3, 6, 7 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 1
      1 2 3 4 5 6 7 8 9 0
      < Machines >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 1
      1 2 4 8 5 9 3 6 7 0
< Parts >
=====
( 1) 1 * 1 1 1 1 *
( 2) 3 * 1 1 1 *
( 3) 6 * 1 1 1 1 *
=====
( 4) 4 * 1 1 *
( 5) 7 * 1 1 1 *
=====
( 6) 2 * 1 1 1 *
( 7) 5 * 1 1 1 *
( 8) 8 * 1 1 1 *
=====
* * * * * * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 2, 4, 8 }
Machine Cell[ 2] = { 5, 9 }
Machine Cell[ 3] = { 3, 6, 7, 10 }
=====
Part Family[ 1] = { 1, 3, 6 }
Part Family[ 2] = { 4, 7 }
Part Family[ 3] = { 2, 5, 8 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 10
No. of part types = 8
No. of cells = 3
Machine cell size = 4
Total no. of 1's in the original MPIM : |A| = 26
Matrix density = 0.325
Total no. of within-block 1's = 24
No. of exceptional elements (EES) = 2
No. of voids = 4
Sum of EES and voids = 6
Group Capability Index (GCI) = 92.31 %
grouping efficiency (GE) = 90.93 %
Grouping efficacy (GF) = 80.00 %
Machine utilization (MU) = 85.71 %
No. of redundant machines (RMs) = 0
=====
```

Problem(33) --> Data file name : DB_15_ChandraRaja(1989)_4_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 13, 15, 21, 22 }
Part[ 2] = { 3, 20, 24 }
Part[ 3] = { 14, 23, 24 }
Part[ 4] = { 8, 12, 15, 18 }
Part[ 5] = { 6, 8, 12, 15, 18 }
Part[ 6] = { 9, 10 }
Part[ 7] = { 9, 10, 17, 19 }
Part[ 8] = { 4, 16 }
Part[ 9] = { 1, 13, 21 }
Part[10] = { 2, 5, 11, 19, 21 }
Part[11] = { 3, 20 }
Part[12] = { 3, 20 }
Part[13] = { 2, 11, 19 }
Part[14] = { 2, 5, 14, 19 }
Part[15] = { 3, 20 }
Part[16] = { 1, 14, 21, 22, 31 }
Part[17] = { 1, 13, 22 }
Part[18] = { 6, 12, 15, 18 }
Part[19] = { 1, 4, 16, 20 }
Part[20] = { 10, 12, 17 }
Part[21] = { 4, 16 }
Part[22] = { 2, 5, 11, 19 }
Part[23] = { 3, 20 }
Part[24] = { 3, 12, 20 }
Part[25] = { 7, 14, 23 }
Part[26] = { 6, 8, 10, 15, 18 }
Part[27] = { 5, 6, 8, 12, 15, 18 }
Part[28] = { 4 }
Part[29] = { 9, 17 }
Part[30] = { 6, 8, 12, 18, 22 }
Part[31] = { 17, 20 }
Part[32] = { 7, 16, 23, 24 }
Part[33] = { 1, 2, 9, 13, 21, 22 }
Part[34] = { 3, 20 }
Part[35] = { 5, 11, 19 }
Part[36] = { 2, 5, 11, 19 }
Part[37] = { 15, 16 }
Part[38] = { 6, 4, 16 }
Part[39] = { 4, 16 }
Part[40] = { 7, 9, 17 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 1 1 1 0 2 0 0 1 1 0 1 0 1 2 2 0 1 1 0 1 2 2
      6 8 2 5 8 3 0 2 5 1 9 4 6 7 4 3 4 9 0 7 1 3 1 2
< Parts >
===== * * * * *
( 1) 4 * 1 1 1 1
( 2) 5 * 1 1 1 1
( 3) 18 * 1 1 1 1
( 4) 26 * 1 1 1 1
( 5) 27 * 1 1 1 1 1 1
( 6) 30 * 1 1 1 1
( 7) 37 * 1
===== * * * * *
( 8) 2 * 1 1
( 9) 11 * 1 1
(10) 12 * 1 1
(11) 15 * 1 1
(12) 23 * 1 1
(13) 24 * 1 1
(14) 31 * 1
=====

```



```

( 15) 34 *          1 1
=====
( 16) 10 *          1 1 1 1
( 17) 13 *          1 1 1
( 18) 14 *          1 1 1      1
( 19) 22 *          1 1 1 1
( 20) 35 *          1 1 1
( 21) 36 *          1 1 1 1
=====
( 22) 8  *          1 1
( 23) 19 *          1 1      1
( 24) 21 *          1 1
( 25) 28 *          1
( 26) 38 * 1        1 1
( 27) 39 *          1 1
=====
( 28) 3  *          1 1 1
( 29) 25 *          1 1 1
( 30) 32 *          1 1 1 1
=====
( 31) 6  *          1 1
( 32) 7  *          1 1 1
( 33) 20 *          1 1
( 34) 29 *          1 1
( 35) 40 *          1 1
=====
( 36) 1  *          1      1 1 1
( 37) 9  *          1 1 1
( 38) 16 *          1      1 1
( 39) 17 *          1 1 1
( 40) 33 *          1      1 1 1
=====
* * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 6, 8, 12, 15, 18 }
Machine Cell[ 2] = { 3, 20 }
Machine Cell[ 3] = { 2, 5, 11, 19 }
Machine Cell[ 4] = { 4, 16 }
Machine Cell[ 5] = { 7, 14, 23, 24 }
Machine Cell[ 6] = { 9, 10, 17 }
Machine Cell[ 7] = { 1, 13, 21, 22 }
=====
Part Family[ 1] = { 4, 5, 18, 26, 27, 30, 37 }
Part Family[ 2] = { 2, 11, 12, 15, 23, 24, 31, 34 }
Part Family[ 3] = { 10, 13, 14, 22, 35, 36 }
Part Family[ 4] = { 8, 19, 21, 28, 38, 39 }
Part Family[ 5] = { 3, 25, 32 }
Part Family[ 6] = { 6, 7, 20, 29, 40 }
Part Family[ 7] = { 1, 9, 16, 17, 33 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 24
No. of part types              = 40
No. of cells                   = 7
Machine cell size              = 5
Total no. of 1's in the original MPIM : |A| = 130
Matrix density                  = 0.135
Total no. of within-block 1's = 110
No. of exceptional elements (EEs) = 20
No. of voids                   = 24
Sum of EEs and voids          = 44
Group Capability Index (GCI)    = 84.62 %
grouping efficiency (GE)       = 89.83 %
Grouping efficacy (GF)         = 71.43 %
Machine utilization (MU)       = 82.09 %
No. of redundant machines (RMs) = 0
=====

```

Problem(34) --> Data file name : DB_16_VakhariaWemmerlove(1990)_12x19.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====  
Part[ 1] = { 1, 4, 8, 9 }  
Part[ 2] = { 1, 4, 7, 8 }  
Part[ 3] = { 1, 2, 4, 7, 8, 9 }  
Part[ 4] = { 1, 4, 7, 9 }  
Part[ 5] = { 1, 6, 7, 9, 10 }  
Part[ 6] = { 6, 7, 8, 9, 10 }  
Part[ 7] = { 4, 6, 8, 9 }  
Part[ 8] = { 2, 3, 4, 5, 6, 8, 9 }  
Part[ 9] = { 3, 4, 5, 6, 8, 9 }  
Part[10] = { 4, 7, 8 }  
Part[11] = { 6 }  
Part[12] = { 7, 11, 12 }  
Part[13] = { 11, 12 }  
Part[14] = { 7, 10, 11 }  
Part[15] = { 1, 7, 10, 11, 12 }  
Part[16] = { 1, 7, 10, 11, 12 }  
Part[17] = { 7, 11, 12 }  
Part[18] = { 6, 7, 10 }  
Part[19] = { 12 }  
=====
```

< Block Diagonal Solution Matrix >

```
      < Locations >  
      0 0 0 0 0 0 0 0 0 0 0 0  
      0 0 0 0 0 0 0 0 0 1 1 1  
      1 2 3 4 5 6 7 8 9 0 1 2  
      < Machines >  
      0 0 0 0 0 0 0 0 0 0 0 0  
      0 0 0 0 1 1 1 0 0 0 0 0  
      3 5 1 7 0 1 2 2 4 6 8 9  
      * * * * * * * * * * * *  
===== * = = = = = *  
( 1) 2 * 1 1 1 1 *  
( 2) 4 * 1 1 1 1 *  
( 3) 5 * 1 1 1 1 *  
( 4) 12 * 1 1 1 1 *  
( 5) 13 * 1 1 1 1 *  
( 6) 14 * 1 1 1 1 *  
( 7) 15 * 1 1 1 1 1 *  
( 8) 16 * 1 1 1 1 1 *  
( 9) 17 * 1 1 1 1 *  
(10) 18 * 1 1 1 1 *  
(11) 19 * 1 1 1 1 *  
===== * = = = = = *  
(12) 1 * 1 1 1 1 *  
(13) 3 * 1 1 1 1 *  
(14) 6 * 1 1 1 1 *  
(15) 7 * 1 1 1 1 *  
(16) 8 * 1 1 1 1 1 *  
(17) 9 * 1 1 1 1 1 *  
(18) 10 * 1 1 1 1 *  
(19) 11 * 1 1 1 1 *  
===== * * * * * * * * * * * *
```

< Machine cells and Part families >

```
=====  
Machine Cell[ 1] = { 3, 5 } --> Residual cell  
Machine Cell[ 2] = { 1, 7, 10, 11, 12 }  
Machine Cell[ 3] = { 2, 4, 6, 8, 9 }  
=====  
Part Family[ 1] --> Empty Part family  
Part Family[ 2] = { 2, 4, 5, 12, 13, 14, 15, 16, 17, 18, 19 }  
Part Family[ 3] = { 1, 3, 6, 7, 8, 9, 10, 11 }  
=====
```

< Summary of the performance measures >

=====

No. of machines	= 12
No. of part types	= 19
No. of cells	= 3
Machine cell size	= 5
Total no. of 1's in the original MPIM : A	= 74
Matrix density	= 0.325
Total no. of within-block 1's	= 57
No. of exceptional elements (EEs)	= 17
No. of voids	= 38
Sum of EEs and voids	= 55
Group Capability Index (GCI)	= 77.03 %
grouping efficiency (GE)	= 73.61 %
Grouping efficacy (GF)	= 50.89 %
Machine utilization (MU)	= 60.00 %
No. of redundant machines (RMs)	= 2

=====

[illegible]

```

( 22) 25 * 1 1 1 *
=====
( 23) 1 * 1 1 1 *
( 24) 9 * 1 1 1 *
( 25) 16 * 1 1 1 1 *
( 26) 17 * 1 1 1 *
=====
( 27) 6 * 1 1 *
( 28) 7 * 1 1 1 *
( 29) 20 * 1 1 *
( 30) 29 * 1 1 *
=====
* * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 6, 8, 12, 15, 18 }
Machine Cell[ 2] = { 3, 20 }
Machine Cell[ 3] = { 2, 5, 11, 19 }
Machine Cell[ 4] = { 4, 16 }
Machine Cell[ 5] = { 7, 14, 23, 24 }
Machine Cell[ 6] = { 1, 13, 21, 22 }
Machine Cell[ 7] = { 9, 10, 17 }
=====
Part Family[ 1] = { 4, 5, 18, 26, 27, 30 }
Part Family[ 2] = { 2, 11, 12, 15, 23, 24 }
Part Family[ 3] = { 10, 13, 14, 22 }
Part Family[ 4] = { 8, 19, 21, 28 }
Part Family[ 5] = { 3, 25 }
Part Family[ 6] = { 1, 9, 16, 17 }
Part Family[ 7] = { 6, 7, 20, 29 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 24
No. of part types = 30
No. of cells = 7
Machine cell size = 5
Total no. of 1's in the original MPIM : |A| = 99
Matrix density = 0.138
Total no. of within-block 1's = 87
No. of exceptional elements (EEs) = 12
No. of voids = 15
Sum of EEs and voids = 27
Group Capability Index (GCI) = 87.88 %
grouping efficiency (GE) = 91.68 %
Grouping efficacy (GF) = 76.32 %
Machine utilization (MU) = 85.29 %
No. of redundant machines (RMs) = 0
=====

```

Problem(36) --> Data file name : DB_18_MiltenburgZhang(1991)_10x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====  
Part[ 1] = { 1, 2, 4, 8 }  
Part[ 2] = { 3, 6, 10 }  
Part[ 3] = { 1, 4, 8 }  
Part[ 4] = { 5, 9 }  
Part[ 5] = { 3, 6, 7 }  
Part[ 6] = { 1, 2, 4, 8 }  
Part[ 7] = { 5, 9, 10 }  
Part[ 8] = { 3, 6, 7 }  
=====
```

< Block Diagonal Solution Matrix >

```
      < Locations >  
      0 0 0 0 0 0 0 0 0 0  
      0 0 0 0 0 0 0 0 0 1  
      1 2 3 4 5 6 7 8 9 0  
      < Machines >  
      0 0 0 0 0 0 0 0 0 0  
      0 0 0 0 0 0 0 0 0 1  
      1 2 4 8 5 9 3 6 7 0  
< Parts >  
===== * * * * * * * * * * *  
( 1) 1 * 1 1 1 1 *  
( 2) 3 * 1 1 1 *  
( 3) 6 * 1 1 1 1 *  
===== * = = = = = *  
( 4) 4 * 1 1 *  
( 5) 7 * 1 1 1 *  
===== * = = = = = *  
( 6) 2 * 1 1 1 *  
( 7) 5 * 1 1 1 *  
( 8) 8 * 1 1 1 *  
===== * * * * * * * * * * *
```

< Machine cells and Part families >

```
=====  
Machine Cell[ 1] = { 1, 2, 4, 8 }  
Machine Cell[ 2] = { 5, 9 }  
Machine Cell[ 3] = { 3, 6, 7, 10 }  
=====  
Part Family[ 1] = { 1, 3, 6 }  
Part Family[ 2] = { 4, 7 }  
Part Family[ 3] = { 2, 5, 8 }  
=====
```

< Summary of the performance measures >

```
=====  
No. of machines = 10  
No. of part types = 8  
No. of cells = 3  
Machine cell size = 4  
Total no. of 1's in the original MPIM : |A| = 25  
Matrix density = 0.313  
Total no. of within-block 1's = 24  
No. of exceptional elements (EES) = 1  
No. of voids = 4  
Sum of EES and voids = 5  
Group Capability Index (GCI) = 96.00 %  
grouping efficiency (GE) = 91.90 %  
Grouping efficacy (GF) = 82.76 %  
Machine utilization (MU) = 85.71 %  
No. of redundant machines (RMs) = 0  
=====
```

Machine Cell	[1]	= { 1, 3, 7, 11, 12 }
Machine Cell	[2]	= { 4, 9, 10, 15, 16 }
Machine Cell	[3]	= { 6, 14, 17 }
Machine Cell	[4]	= { 2, 5, 8, 13 }
=====		
Part Family	[1]	= { 3, 6, 9, 12, 14, 18, 20 }
Part Family	[2]	= { 4, 5, 11, 13, 16 }
Part Family	[3]	= { 2, 8, 17 }

Part Family[4] = { 1, 7, 10, 15, 19 }

< Summary of the performance measures >

No. of machines	= 17
No. of part types	= 20
No. of cells	= 4
Machine cell size	= 5
Total no. of 1's in the original MPIM : A	= 78
Matrix density	= 0.229
Total no. of within-block 1's	= 74
No. of exceptional elements (EES)	= 4
No. of voids	= 15
Sum of EES and voids	= 19
Group Capability Index (GCI)	= 94.87 %
grouping efficiency (GE)	= 90.78 %
Grouping efficacy (GF)	= 79.57 %
Machine utilization (MU)	= 83.15 %
No. of redundant machines (RMs)	= 0

Problem(38) --> Data file name : DB_20_SeifoddiniHsu(1994)_7x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====  
Part[ 1] = { 2, 4, 6 }  
Part[ 2] = { 1 }  
Part[ 3] = { 1, 4, 7 }  
Part[ 4] = { 6, 7 }  
Part[ 5] = { 2, 5, 7 }  
Part[ 6] = { 4, 7 }  
Part[ 7] = { 1, 7 }  
Part[ 8] = { 5, 6 }  
Part[ 9] = { 6, 7 }  
Part[10] = { 3, 6 }  
Part[11] = { 2, 3 }  
=====
```

< Block Diagonal Solution Matrix >

```
      < Locations >  
      0 0 0 0 0 0 0  
      0 0 0 0 0 0 0  
      1 2 3 4 5 6 7  
      < Machines >  
      0 0 0 0 0 0 0  
      0 0 0 0 0 0 0  
      1 4 7 2 3 5 6  
< Parts >  
===== * * * * * * * * *  
( 1) 2 * 1 * * * * *  
( 2) 3 * 1 1 1 * * *  
( 3) 6 * 1 1 * * *  
( 4) 7 * 1 1 * * *  
===== * = = = = = *  
( 5) 1 * 1 1 1 *  
( 6) 4 * 1 1 1 *  
( 7) 5 * 1 1 1 *  
( 8) 8 * 1 1 1 *  
( 9) 9 * 1 1 1 *  
(10)10 * 1 1 *  
(11)11 * 1 1 *  
===== * * * * * * * * *
```

< Machine cells and Part families >

```
=====  
Machine Cell[ 1] = { 1, 4, 7 }  
Machine Cell[ 2] = { 2, 3, 5, 6 }  
=====  
Part Family[ 1] = { 2, 3, 6, 7 }  
Part Family[ 2] = { 1, 4, 5, 8, 9, 10, 11 }  
=====
```

< Summary of the performance measures >

```
=====  
No. of machines = 7  
No. of part types = 11  
No. of cells = 2  
Machine cell size = 4  
Total no. of 1's in the original MPIM : |A| = 24  
Matrix density = 0.312  
Total no. of within-block 1's = 20  
No. of exceptional elements (EEs) = 4  
No. of voids = 20  
Sum of EEs and voids = 24  
Group Capability Index (GCI) = 83.33 %  
grouping efficiency (GE) = 69.59 %  
Grouping efficacy (GF) = 45.45 %  
Machine utilization (MU) = 50.00 %  
No. of redundant machines (RMs) = 0  
=====
```

Problem(39) --> Data file name : DB_21_Shargal(1995)_10x38.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 2 }
Part[ 2] = { 3, 4 }
Part[ 3] = { 4, 5 }
Part[ 4] = { 3, 6 }
Part[ 5] = { 5, 7 }
Part[ 6] = { 7, 8 }
Part[ 7] = { 5, 9 }
Part[ 8] = { 5, 6, 9 }
Part[ 9] = { 3, 4, 10 }
Part[10] = { 7, 8 }
Part[11] = { 5, 7 }
Part[12] = { 5, 7 }
Part[13] = { 7, 8 }
Part[14] = { 3, 8 }
Part[15] = { 3, 8 }
Part[16] = { 1, 7 }
Part[17] = { 4, 5 }
Part[18] = { 2, 3 }
Part[19] = { 4, 5 }
Part[20] = { 3, 4 }
Part[21] = { 3, 7 }
Part[22] = { 4, 7, 8 }
Part[23] = { 5, 9 }
Part[24] = { 4, 5 }
Part[25] = { 4, 7, 8 }
Part[26] = { 7, 8 }
Part[27] = { 2, 9 }
Part[28] = { 4, 7, 8 }
Part[29] = { 4, 5 }
Part[30] = { 7, 8 }
Part[31] = { 4, 7, 8 }
Part[32] = { 6, 10 }
Part[33] = { 6, 10 }
Part[34] = { 1, 2, 3 }
Part[35] = { 6, 7 }
Part[36] = { 3, 4, 10 }
Part[37] = { 2, 3 }
Part[38] = { 4, 5 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 1
      1 2 3 4 5 6 7 8 9 0
      < Machines >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 1
      2 3 4 5 7 8 1 9 6 0
< Parts >
=====
( 1) 2 * 1 1 *
( 2) 4 * 1 *
( 3) 9 * 1 1 *
( 4) 15 * 1 *
( 5) 18 * 1 1 *
( 6) 20 * 1 1 *
( 7) 27 * 1 *
( 8) 34 * 1 1 *
( 9) 36 * 1 1 *
(10) 37 * 1 1 *
=====
(11) 3 * 1 1 *
(12) 8 * 1 *
(13) 17 * 1 1 *
(14) 19 * 1 1 *
(15) 24 * 1 1 *
(16) 29 * 1 1 *

```

```

( 17) 38 *      1 1      *
=====
( 18)  5 *      1 1      *
( 19)  6 *      1 1      *
( 20) 10 *      1 1      *
( 21) 11 *      1 1      *
( 22) 12 *      1 1      *
( 23) 13 *      1 1      *
( 24) 14 *      1 1      *
( 25) 21 *      1 1      *
( 26) 22 *      1 1      *
( 27) 25 *      1 1      *
( 28) 26 *      1 1      *
( 29) 28 *      1 1      *
( 30) 30 *      1 1      *
( 31) 31 *      1 1      *
=====
( 32)  1 *      1 1      *
( 33)  7 *      1 1      *
( 34) 16 *      1 1      *
( 35) 23 *      1 1      *
=====
( 36) 32 *      1 1      *
( 37) 33 *      1 1      *
( 38) 35 *      1 1      *
=====
* * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 2, 3 }
Machine Cell[ 2] = { 4, 5 }
Machine Cell[ 3] = { 7, 8 }
Machine Cell[ 4] = { 1, 9 }
Machine Cell[ 5] = { 6, 10 }
=====
Part Family[ 1] = { 2, 4, 9, 15, 18, 20, 27, 34, 36, 37 }
Part Family[ 2] = { 3, 8, 17, 19, 24, 29, 38 }
Part Family[ 3] = { 5, 6, 10, 11, 12, 13, 14, 21, 22, 25, 26, 28, 30, 31 }
Part Family[ 4] = { 1, 7, 16, 23 }
Part Family[ 5] = { 32, 33, 35 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 10
No. of part types              = 38
No. of cells                   = 5
Machine cell size              = 3
Total no. of 1's in the original MPIM : |A| = 84
Matrix density                  = 0.221
Total no. of within-block 1's  = 58
No. of exceptional elements (EEs) = 26
No. of voids                   = 18
Sum of EEs and voids          = 44
Group Capability Index (GCI)    = 69.05 %
grouping efficiency (GE)       = 83.88 %
Grouping efficacy (GF)         = 56.86 %
Machine utilization (MU)       = 76.32 %
No. of redundant machines (RMs) = 0
=====

```

Problem(40) --> Data file name : DB_22_Joiner(1996)_20x35.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 3, 7, 8, 17 }
Part[ 2] = { 2, 4, 13, 14, 18 }
Part[ 3] = { 1, 3, 7, 8, 17 }
Part[ 4] = { 11, 12, 15, 16, 19 }
Part[ 5] = { 3, 7, 8, 17 }
Part[ 6] = { 11, 12, 15, 16 }
Part[ 7] = { 2, 4, 14 }
Part[ 8] = { 5, 6, 9, 10, 20 }
Part[ 9] = { 11, 12, 15, 16, 19 }
Part[10] = { 2, 14, 18 }
Part[11] = { 11, 12, 15, 16, 19 }
Part[12] = { 2, 4, 13, 14, 18 }
Part[13] = { 2, 4, 13, 14, 18 }
Part[14] = { 5, 6, 9, 10, 20 }
Part[15] = { 3, 7, 8, 17 }
Part[16] = { 5, 6, 10 }
Part[17] = { 3, 7, 8, 17 }
Part[18] = { 2, 14, 18 }
Part[19] = { 6, 9, 10, 20 }
Part[20] = { 1, 7, 8, 17 }
Part[21] = { 11, 12, 15, 16, 19 }
Part[22] = { 6, 9, 10 }
Part[23] = { 1, 7, 8, 17, 20 }
Part[24] = { 2, 4, 13, 14, 18 }
Part[25] = { 1, 8, 17 }
Part[26] = { 6, 9, 10, 20 }
Part[27] = { 2, 4, 14 }
Part[28] = { 11, 15, 16, 19 }
Part[29] = { 3, 8, 17 }
Part[30] = { 11, 15, 16, 19 }
Part[31] = { 2, 3, 14, 18 }
Part[32] = { 11, 16, 19 }
Part[33] = { 12 }
Part[34] = { 5, 6 }
Part[35] = { 11 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 1 1 1 0 0 0 0 0 1 0 0 0 1 2 1 1 1 1
      2 4 3 4 8 1 3 7 8 7 5 6 9 0 0 1 2 5 6 9
< Parts >
=====
( 1) 2 * 1 1 1 1 1
( 2) 7 * 1 1
( 3) 10 * 1
( 4) 12 * 1 1 1 1 1
( 5) 13 * 1 1 1 1 1
( 6) 18 * 1
( 7) 24 * 1 1 1 1 1
( 8) 27 * 1 1
( 9) 31 * 1 1 1
=====
(10) 1 * 1 1 1 1 1
(11) 3 * 1 1 1 1 1
(12) 5 * 1 1 1 1
(13) 15 * 1 1 1 1
(14) 17 * 1 1 1 1
(15) 20 * 1 1 1 1
(16) 23 * 1 1 1 1 1
(17) 25 * 1 1 1
(18) 29 * 1 1 1
=====

```

```

( 19)  8  *          1 1 1 1 1          *
( 20) 14  *          1 1 1 1 1          *
( 21) 16  *          1 1 1          *
( 22) 19  *          1 1 1 1          *
( 23) 22  *          1 1 1          *
( 24) 26  *          1 1 1 1          *
( 25) 34  *          1 1          *
===== * = = = = = = = = = = = = = = *
( 26)  4  *          1 1 1 1 1          *
( 27)  6  *          1 1 1 1          *
( 28)  9  *          1 1 1 1 1          *
( 29) 11  *          1 1 1 1 1          *
( 30) 21  *          1 1 1 1 1          *
( 31) 28  *          1 1 1 1          *
( 32) 30  *          1 1 1 1          *
( 33) 32  *          1 1 1          *
( 34) 33  *          1          *
( 35) 35  *          1          *
===== * * * * * * * * * * * * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 2, 4, 13, 14, 18 }
Machine Cell[ 2] = { 1, 3, 7, 8, 17 }
Machine Cell[ 3] = { 5, 6, 9, 10, 20 }
Machine Cell[ 4] = { 11, 12, 15, 16, 19 }
=====
Part Family[ 1] = { 2, 7, 10, 12, 13, 18, 24, 27, 31 }
Part Family[ 2] = { 1, 3, 5, 15, 17, 20, 23, 25, 29 }
Part Family[ 3] = { 8, 14, 16, 19, 22, 26, 34 }
Part Family[ 4] = { 4, 6, 9, 11, 21, 28, 30, 32, 33, 35 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 20
No. of part types              = 35
No. of cells                   = 4
Machine cell size              = 5
Total no. of 1's in the original MPIM : |A| = 136
Matrix density                 = 0.194
Total no. of within-block 1's = 134
No. of exceptional elements (EEs) = 2
No. of voids                  = 41
Sum of EEs and voids          = 43
Group Capability Index (GCI)   = 98.53 %
grouping efficiency (GE)      = 88.10 %
Grouping efficacy (GF)        = 75.71 %
Machine utilization (MU)       = 76.57 %
No. of redundant machines (RMs) = 0
=====

```

[illegible]

```

===== * = = = = = = = = = = = = = = = = = = = = = *
( 15) 8 * 1 1 *
( 16) 19 * 1 1 *
( 17) 21 * 1 *
( 18) 28 * 1 1 *
( 19) 37 * 1 *
( 20) 38 * 1 1 1 *
( 21) 39 * 1 1 *
===== * = = = = = = = = = = = = = = = = = = = = = *
( 22) 4 * 1 1 1 1 1 *
( 23) 5 * 1 1 1 1 *
( 24) 18 * 1 1 1 1 1 *
( 25) 26 * 1 1 1 1 *
( 26) 27 * 1 1 1 1 *
( 27) 30 * 1 1 1 1 1 1 *
===== * = = = = = = = = = = = = = = = = = = = = = *
( 28) 1 * 1 1 1 *
( 29) 9 * 1 1 1 *
( 30) 16 * 1 1 1 *
( 31) 17 * 1 1 1 1 *
( 32) 33 * 1 1 1 *
===== * = = = = = = = = = = = = = = = = = = = = = *
( 33) 3 * 1 1 1 1 *
( 34) 25 * 1 1 *
( 35) 32 * 1 1 1 1 *
===== * = = = = = = = = = = = = = = = = = = = = = *
( 36) 6 * 1 1 1 *
( 37) 7 * 1 1 *
( 38) 20 * 1 1 *
( 39) 29 * 1 1 1 *
( 40) 40 * 1 1 1 *
===== * * * * * * * * * * * * * * * * * * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 2, 5, 11, 19 }
Machine Cell[ 2] = { 3, 20 }
Machine Cell[ 3] = { 4, 16 }
Machine Cell[ 4] = { 6, 8, 12, 15, 18 }
Machine Cell[ 5] = { 1, 13, 21, 22 }
Machine Cell[ 6] = { 7, 14, 23, 24 }
Machine Cell[ 7] = { 9, 10, 17 }
=====
Part Family[ 1] = { 10, 13, 14, 22, 35, 36 }
Part Family[ 2] = { 2, 11, 12, 15, 23, 24, 31, 34 }
Part Family[ 3] = { 8, 19, 21, 28, 37, 38, 39 }
Part Family[ 4] = { 4, 5, 18, 26, 27, 30 }
Part Family[ 5] = { 1, 9, 16, 17, 33 }
Part Family[ 6] = { 3, 25, 32 }
Part Family[ 7] = { 6, 7, 20, 29, 40 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 24
No. of part types = 40
No. of cells = 7
Machine cell size = 5
Total no. of 1's in the original MPIM : |A| = 119
Matrix density = 0.124
Total no. of within-block 1's = 112
No. of exceptional elements (EEs) = 7
No. of voids = 19
Sum of EEs and voids = 26
Group Capability Index (GCI) = 94.12 %
grouping efficiency (GE) = 92.33 %
Grouping efficacy (GF) = 81.16 %
Machine utilization (MU) = 85.50 %
No. of redundant machines (RMs) = 0
=====

```

Problem(42) --> Data file name : DB_24_NairNarendran(1996)_Figure_4_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 2, 13, 22 }
Part[ 2] = { 2, 3, 20 }
Part[ 3] = { 7, 14, 23, 24 }
Part[ 4] = { 5, 6, 8, 12, 15, 20 }
Part[ 5] = { 8, 15, 18 }
Part[ 6] = { 9, 10, 13, 17 }
Part[ 7] = { 9, 17 }
Part[ 8] = { 4, 16 }
Part[ 9] = { 13, 20, 21, 22 }
Part[10] = { 5, 11, 19 }
Part[11] = { 3, 20 }
Part[12] = { 20 }
Part[13] = { 2, 5, 19 }
Part[14] = { 2, 11, 19 }
Part[15] = { 3, 12 }
Part[16] = { 13, 18, 21 }
Part[17] = { 1, 21, 22 }
Part[18] = { 8, 9, 12, 15, 18 }
Part[19] = { 3, 4, 16 }
Part[20] = { 9, 10 }
Part[21] = { 4 }
Part[22] = { 2, 11, 19 }
Part[23] = { 2, 3, 17, 20 }
Part[24] = { 20 }
Part[25] = { 14, 24 }
Part[26] = { 6, 8, 12, 18 }
Part[27] = { 2, 6, 12, 15, 18 }
Part[28] = { 4, 16 }
Part[29] = { 10, 17 }
Part[30] = { 6, 8, 12, 15 }
Part[31] = { 3, 20 }
Part[32] = { 6, 7, 14, 23, 24 }
Part[33] = { 1, 4, 13, 22 }
Part[34] = { 3, 20 }
Part[35] = { 5, 7, 11, 13 }
Part[36] = { 2, 5, 10, 11, 19 }
Part[37] = { 16 }
Part[38] = { 4, 16, 24 }
Part[39] = { 4, 16 }
Part[40] = { 10, 17, 20 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 1 0 2 0 0 1 1 0 1 1 0 1 2 2 0 0 1 1 1 0 1 2 2
      4 6 3 0 2 5 1 9 9 0 7 1 3 1 2 6 8 2 5 8 7 4 3 4
< Parts >
===== * * * * *
( 1) 8 * 1 1 *
( 2) 19 * 1 1 1 *
( 3) 21 * 1 *
( 4) 28 * 1 1 *
( 5) 37 * 1 *
( 6) 38 * 1 1 1 *
( 7) 39 * 1 1 *
===== * = = = = =
( 8) 2 * 1 1 1 *
( 9) 11 * 1 1 *
(10) 12 * 1 *
(11) 15 * 1 1 *
(12) 23 * 1 1 1 1 *
(13) 24 * 1 *
(14) 31 * 1 1 *

```



```

( 15) 34 *      1 1
=====
( 16) 10 *      1 1 1
( 17) 13 *      1 1 1
( 18) 14 *      1 1 1
( 19) 22 *      1 1 1
( 20) 35 *      1 1 1      1      1
( 21) 36 *      1 1 1 1      1
=====
( 22) 6  *      1 1 1      1
( 23) 7  *      1 1
( 24) 20 *      1 1
( 25) 29 *      1 1
( 26) 40 *      1 1
=====
( 27) 1  *      1      1 1 1
( 28) 9  *      1      1 1 1
( 29) 16 *      1      1 1      1
( 30) 17 *      1 1 1
( 31) 33 * 1      1 1 1
=====
( 32) 4  *      1 1      1 1 1 1
( 33) 5  *      1 1 1
( 34) 18 *      1      1 1 1 1
( 35) 26 *      1 1 1 1
( 36) 27 *      1      1 1 1 1
( 37) 30 *      1 1 1 1
=====
( 38) 3  *      1 1 1 1
( 39) 25 *      1 1
( 40) 32 *      1      1 1 1
=====
* * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 4, 16 }
Machine Cell[ 2] = { 3, 20 }
Machine Cell[ 3] = { 2, 5, 11, 19 }
Machine Cell[ 4] = { 9, 10, 17 }
Machine Cell[ 5] = { 1, 13, 21, 22 }
Machine Cell[ 6] = { 6, 8, 12, 15, 18 }
Machine Cell[ 7] = { 7, 14, 23, 24 }
=====
Part Family[ 1] = { 8, 19, 21, 28, 37, 38, 39 }
Part Family[ 2] = { 2, 11, 12, 15, 23, 24, 31, 34 }
Part Family[ 3] = { 10, 13, 14, 22, 35, 36 }
Part Family[ 4] = { 6, 7, 20, 29, 40 }
Part Family[ 5] = { 1, 9, 16, 17, 33 }
Part Family[ 6] = { 4, 5, 18, 26, 27, 30 }
Part Family[ 7] = { 3, 25, 32 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 24
No. of part types              = 40
No. of cells                   = 7
Machine cell size              = 5
Total no. of 1's in the original MPIM : |A| = 121
Matrix density                 = 0.126
Total no. of within-block 1's = 101
No. of exceptional elements (EEs) = 20
No. of voids                   = 30
Sum of EEs and voids          = 50
Group Capability Index (GCI)   = 83.47 %
grouping efficiency (GE)       = 87.34 %
Grouping efficacy (GF)        = 66.89 %
Machine utilization (MU)       = 77.10 %
No. of redundant machines (RMs) = 0
=====

```

Problem(43) --> Data file name :
DB_25_SeifoddiniDjassemi(1996)_Version_3_7x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 2, 3 }
Part[ 2] = { 2, 3 }
Part[ 3] = { 1, 5, 6 }
Part[ 4] = { 4, 7 }
Part[ 5] = { 4, 7 }
Part[ 6] = { 2, 3 }
Part[ 7] = { 1, 5, 6 }
Part[ 8] = { 3, 7 }
Part[ 9] = { 2, 3 }
Part[10] = { 4, 7 }
Part[11] = { 1, 5, 6 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
      < Machines >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 5 6 2 3 4 7
< Parts >
===== * * * * *
( 1) 3 * 1 1 1 *
( 2) 7 * 1 1 1 *
( 3) 11 * 1 1 1 *
===== * = = = = *
( 4) 1 * 1 1 *
( 5) 2 * 1 1 *
( 6) 6 * 1 1 *
( 7) 8 * 1 1 *
( 8) 9 * 1 1 *
===== * = = = = *
( 9) 4 * 1 1 *
(10) 5 * 1 1 *
(11) 10 * 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 5, 6 }
Machine Cell[ 2] = { 2, 3 }
Machine Cell[ 3] = { 4, 7 }
=====
Part Family[ 1] = { 3, 7, 11 }
Part Family[ 2] = { 1, 2, 6, 8, 9 }
Part Family[ 3] = { 4, 5, 10 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 7
No. of part types = 11
No. of cells = 3
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 25
Matrix density = 0.325
Total no. of within-block 1's = 24
No. of exceptional elements (EEs) = 1
No. of voids = 1
Sum of EEs and voids = 2
Group Capability Index (GCI) = 96.00 %
grouping efficiency (GE) = 97.04 %
Grouping efficacy (GF) = 92.31 %
Machine utilization (MU) = 96.00 %
No. of redundant machines (RMs) = 0

```

=====

Problem(44) --> Data file name :
DB_26_SeifoddiniDjassemi(1996)_Version_4_7x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 2, 4 }
Part[ 2] = { 2, 3 }
Part[ 3] = { 1, 5, 6 }
Part[ 4] = { 4, 7 }
Part[ 5] = { 1, 7 }
Part[ 6] = { 2, 3 }
Part[ 7] = { 1, 5, 6 }
Part[ 8] = { 4, 7 }
Part[ 9] = { 2, 3, 6 }
Part[10] = { 4, 7 }
Part[11] = { 1, 5, 6 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
      < Machines >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 5 6 2 3 4 7
< Parts >
===== * * * * *
( 1) 3 * 1 1 1 *
( 2) 5 * 1 * 1 *
( 3) 7 * 1 1 1 *
( 4) 11 * 1 1 1 *
===== * = = = = *
( 5) 1 * * 1 1 *
( 6) 2 * * 1 1 *
( 7) 6 * * 1 1 *
( 8) 9 * * 1 1 1 *
===== * = = = = *
( 9) 4 * * * 1 1 *
(10) 8 * * * 1 1 *
(11) 10 * * * 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 5, 6 }
Machine Cell[ 2] = { 2, 3 }
Machine Cell[ 3] = { 4, 7 }
=====
Part Family[ 1] = { 3, 5, 7, 11 }
Part Family[ 2] = { 1, 2, 6, 9 }
Part Family[ 3] = { 4, 8, 10 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 7
No. of part types = 11
No. of cells = 3
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 26
Matrix density = 0.338
Total no. of within-block 1's = 23
No. of exceptional elements (EEs) = 3
No. of voids = 3
Sum of EEs and voids = 6
Group Capability Index (GCI) = 88.46 %
grouping efficiency (GE) = 91.29 %
Grouping efficacy (GF) = 79.31 %
Machine utilization (MU) = 88.46 %
No. of redundant machines (RMs) = 0

```

=====

Problem(45) --> Data file name :
DB_27_SeifoddiniDjassemi(1996)_Version_5_7x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 2, 3 }
Part[ 2] = { 2, 3 }
Part[ 3] = { 1, 5, 6 }
Part[ 4] = { 3, 4 }
Part[ 5] = { 4, 7 }
Part[ 6] = { 3, 4 }
Part[ 7] = { 1, 5, 6 }
Part[ 8] = { 4, 7 }
Part[ 9] = { 2, 3 }
Part[10] = { 4, 7 }
Part[11] = { 1, 5, 6 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
      < Machines >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 5 6 2 3 4 7
< Parts >
===== * * * * *
( 1) 3 * 1 1 1 *
( 2) 7 * 1 1 1 *
( 3) 11 * 1 1 1 *
===== * = = = = *
( 4) 1 * 1 1 *
( 5) 2 * 1 1 *
( 6) 4 * 1 1 *
( 7) 6 * 1 1 *
( 8) 9 * 1 1 *
===== * = = = = *
( 9) 5 * 1 1 *
(10) 8 * 1 1 *
(11) 10 * 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 5, 6 }
Machine Cell[ 2] = { 2, 3 }
Machine Cell[ 3] = { 4, 7 }
=====
Part Family[ 1] = { 3, 7, 11 }
Part Family[ 2] = { 1, 2, 4, 6, 9 }
Part Family[ 3] = { 5, 8, 10 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 7
No. of part types = 11
No. of cells = 3
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 25
Matrix density = 0.325
Total no. of within-block 1's = 23
No. of exceptional elements (EEs) = 2
No. of voids = 2
Sum of EEs and voids = 4
Group Capability Index (GCI) = 92.00 %
grouping efficiency (GE) = 94.08 %
Grouping efficacy (GF) = 85.19 %
Machine utilization (MU) = 92.00 %
No. of redundant machines (RMs) = 0

```

=====

Problem(46) --> Data file name : DB_28_PaRkinLi(1997)_6x7.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 4, 6 }
Part[ 2] = { 1, 3, 5 }
Part[ 3] = { 4 }
Part[ 4] = { 1, 2, 3 }
Part[ 5] = { 2, 3, 5 }
Part[ 6] = { 4, 6 }
Part[ 7] = { 2, 3 }
=====
```

< Block Diagonal Solution Matrix >

```

    < Locations >
      0 0 0 0 0 0
      0 0 0 0 0 0
      1 2 3 4 5 6
    < Machines >
      0 0 0 0 0 0
      0 0 0 0 0 0
    < Parts >
      2 3 4 6 1 5
===== * * * * *
( 1) 4 * 1 1 1 *
( 2) 5 * 1 1 1 *
( 3) 7 * 1 1 1 *
===== * = = = = *
( 4) 1 * 1 1 1 *
( 5) 3 * 1 1 1 *
( 6) 6 * 1 1 1 *
===== * = = = = *
( 7) 2 * 1 1 1 *
===== * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 2, 3 }
Machine Cell[ 2] = { 4, 6 }
Machine Cell[ 3] = { 1, 5 }
=====
```

```
Part Family[ 1] = { 4, 5, 7 }
Part Family[ 2] = { 1, 3, 6 }
Part Family[ 3] = { 2 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines                = 6
No. of part types              = 7
No. of cells                   = 3
Machine cell size              = 3
Total no. of 1's in the original MPIM : |A| = 17
Matrix density                 = 0.405
Total no. of within-block 1's = 13
No. of exceptional elements (EEs) = 4
No. of voids                   = 1
Sum of EEs and voids          = 5
Group Capability Index (GCI)    = 76.47 %
grouping efficiency (GE)       = 89.29 %
Grouping efficacy (GF)         = 72.22 %
Machine utilization (MU)       = 92.86 %
No. of redundant machines (RMs) = 0
=====
```


Problem(47) --> Data file name : DB_29_TsengJiao(1997)_24x30.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 13, 15, 21, 22 }
Part[ 2] = { 3, 20 }
Part[ 3] = { 14, 23, 24 }
Part[ 4] = { 8, 12, 15, 18 }
Part[ 5] = { 6, 8, 12, 15, 18 }
Part[ 6] = { 9, 10 }
Part[ 7] = { 9, 10, 17 }
Part[ 8] = { 4, 16 }
Part[ 9] = { 1, 13, 21 }
Part[10] = { 2, 5, 11, 18 }
Part[11] = { 3, 20 }
Part[12] = { 3, 20 }
Part[13] = { 2, 11, 19 }
Part[14] = { 2, 5, 19 }
Part[15] = { 3, 20 }
Part[16] = { 1, 13, 21, 22 }
Part[17] = { 1, 13, 22 }
Part[18] = { 6, 12, 15, 18 }
Part[19] = { 4, 16 }
Part[20] = { 10, 17 }
Part[21] = { 4, 16 }
Part[22] = { 2, 5, 11, 19 }
Part[23] = { 3, 20 }
Part[24] = { 3, 20 }
Part[25] = { 7, 14, 23 }
Part[26] = { 6, 8, 15, 18 }
Part[27] = { 6, 8, 12, 15, 18 }
Part[28] = { 3 }
Part[29] = { 9, 17 }
Part[30] = { 6, 8, 12, 18, 22 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 2 0 0 1 1 1 0 1 2 2 0 1 0 1 1 0 0 1 1 0 1 1 0 1 2 2 2 2 2 2 2
      3 0 6 8 2 5 8 1 3 1 2 4 6 9 0 7 2 5 1 9 7 4 3 4 3 4 3 4 3 4 3 4
< Parts >
=====
( 1) 2 * 1 1 *
( 2) 11 * 1 1 *
( 3) 12 * 1 1 *
( 4) 15 * 1 1 *
( 5) 23 * 1 1 *
( 6) 24 * 1 1 *
( 7) 28 * 1 *
=====
( 8) 4 * 1 1 1 1 *
( 9) 5 * 1 1 1 1 1 *
(10) 18 * 1 1 1 1 1 *
(11) 26 * 1 1 1 1 1 *
(12) 27 * 1 1 1 1 1 *
(13) 30 * 1 1 1 1 1 *
=====
(14) 1 * 1 1 1 1 *
(15) 9 * 1 1 1 1 *
(16) 16 * 1 1 1 1 *
(17) 17 * 1 1 1 1 *
=====
(18) 8 * 1 1 *
(19) 19 * 1 1 *
(20) 21 * 1 1 *
=====
(21) 6 * 1 1 *

```

```

( 22) 7 * 1 1 1 *
( 23) 20 * 1 1 *
( 24) 29 * 1 1 *
===== * = = = = = = = = = = = = = = = = = = *
( 25) 10 * 1 1 1 *
( 26) 13 * 1 1 1 *
( 27) 14 * 1 1 1 *
( 28) 22 * 1 1 1 1 *
===== * = = = = = = = = = = = = = = = = = = *
( 29) 3 * 1 1 1 *
( 30) 25 * 1 1 1 *
===== * * * * * * * * * * * * * * * * * * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 3, 20 }
Machine Cell[ 2] = { 6, 8, 12, 15, 18 }
Machine Cell[ 3] = { 1, 13, 21, 22 }
Machine Cell[ 4] = { 4, 16 }
Machine Cell[ 5] = { 9, 10, 17 }
Machine Cell[ 6] = { 2, 5, 11, 19 }
Machine Cell[ 7] = { 7, 14, 23, 24 }
=====
Part Family[ 1] = { 2, 11, 12, 15, 23, 24, 28 }
Part Family[ 2] = { 4, 5, 18, 26, 27, 30 }
Part Family[ 3] = { 1, 9, 16, 17 }
Part Family[ 4] = { 8, 19, 21 }
Part Family[ 5] = { 6, 7, 20, 29 }
Part Family[ 6] = { 10, 13, 14, 22 }
Part Family[ 7] = { 3, 25 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 24
No. of part types = 30
No. of cells = 7
Machine cell size = 5
Total no. of 1's in the original MPIM : |A| = 89
Matrix density = 0.124
Total no. of within-block 1's = 86
No. of exceptional elements (EEs) = 3
No. of voids = 16
Sum of EEs and voids = 19
Group Capability Index (GCI) = 96.63 %
grouping efficiency (GE) = 91.91 %
Grouping efficacy (GF) = 81.90 %
Machine utilization (MU) = 84.31 %
No. of redundant machines (RMs) = 0
=====

```

Problem(48) --> Data file name : DB_30_NairNarendran(1998)_Table_1_10x12.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 3, 6 }
Part[ 2] = { 2, 5, 8, 10 }
Part[ 3] = { 2, 5, 8, 10 }
Part[ 4] = { 4, 7, 9 }
Part[ 5] = { 1, 3, 4, 6, 8 }
Part[ 6] = { 7, 9 }
Part[ 7] = { 2, 5, 10 }
Part[ 8] = { 2, 10 }
Part[ 9] = { 1, 3, 6, 8 }
Part[10] = { 1, 3, 6 }
Part[11] = { 7 }
Part[12] = { 2, 5, 8 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 1
      1 2 3 4 5 6 7 8 9 0
      < Machines >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 1 0 0 0 0 0 0
      2 5 8 0 1 3 6 4 7 9
< Parts >
===== * * * * *
( 1) 2 * 1 1 1 1 *
( 2) 3 * 1 1 1 1 *
( 3) 7 * 1 1 1 *
( 4) 8 * 1 1 1 *
( 5) 12 * 1 1 1 *
===== * = = = = = *
( 6) 1 * 1 1 1 *
( 7) 5 * 1 1 1 1 *
( 8) 9 * 1 1 1 *
( 9) 10 * 1 1 1 *
===== * = = = = = *
(10) 4 * 1 1 1 *
(11) 6 * 1 1 *
(12) 11 * 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 2, 5, 8, 10 }
Machine Cell[ 2] = { 1, 3, 6 }
Machine Cell[ 3] = { 4, 7, 9 }
=====
Part Family[ 1] = { 2, 3, 7, 8, 12 }
Part Family[ 2] = { 1, 5, 9, 10 }
Part Family[ 3] = { 4, 6, 11 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 10
No. of part types = 12
No. of cells = 3
Machine cell size = 4
Total no. of 1's in the original MPIM : |A| = 36
Matrix density = 0.3
Total no. of within-block 1's = 33
No. of exceptional elements (EEs) = 3
No. of voids = 8
Sum of EEs and voids = 11
Group Capability Index (GCI) = 91.67 %
Grouping efficiency (GE) = 88.35 %
Grouping efficacy (GF) = 75.00 %
Machine utilization (MU) = 80.49 %

```

No. of redundant machines (RMs) = 0
=====

Problem(49) --> Data file name : DB_31_NairNarendran(1998)_Example_3_7x7.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 2, 3 }
Part[ 2] = { 1, 2 }
Part[ 3] = { 3, 4 }
Part[ 4] = { 3, 4 }
Part[ 5] = { 5, 6, 7 }
Part[ 6] = { 3, 5, 6, 7 }
Part[ 7] = { 4, 5, 6, 7 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
      < Machines >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
< Parts >
===== * * * * *
( 1) 1 * 1 1 1 *
( 2) 2 * 1 1 *
===== * = = = = *
( 3) 3 * 1 1 *
( 4) 4 * 1 1 *
===== * = = = = *
( 5) 5 * 1 1 1 *
( 6) 6 * 1 1 1 *
( 7) 7 * 1 1 1 *
===== * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 2 }
Machine Cell[ 2] = { 3, 4 }
Machine Cell[ 3] = { 5, 6, 7 }
=====
Part Family[ 1] = { 1, 2 }
Part Family[ 2] = { 3, 4 }
Part Family[ 3] = { 5, 6, 7 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines                = 7
No. of part types              = 7
No. of cells                   = 3
Machine cell size              = 3
Total no. of 1's in the original MPIM : |A| = 20
Matrix density                 = 0.408
Total no. of within-block 1's = 17
No. of exceptional elements (EEs) = 3
No. of voids                   = 0
Sum of EEs and voids          = 3
Group Capability Index (GCI)   = 85.00 %
grouping efficiency (GE)      = 95.31 %
Grouping efficacy (GF)        = 85.00 %
Machine utilization (MU)       = 100.00%
No. of redundant machines (RMs) = 0
=====
```

Problem(50) --> Data file name : DB_32_NairNarendran(1998)_Example_4_8x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 5, 6 }
Part[ 2] = { 1, 3 }
Part[ 3] = { 1, 2, 4, 7, 8 }
Part[ 4] = { 2, 4, 7, 8 }
Part[ 5] = { 5, 6 }
Part[ 6] = { 2, 4, 5, 7, 8 }
Part[ 7] = { 2, 4, 7, 8 }
Part[ 8] = { 1, 3 }
Part[ 9] = { 1, 3, 6 }
Part[10] = { 4, 5, 6 }
Part[11] = { 1, 3, 7 }
Part[12] = { 5, 6, 7 }
Part[13] = { 1, 3 }
Part[14] = { 1, 2, 3 }
Part[15] = { 5, 6 }
Part[16] = { 1, 3 }
Part[17] = { 1, 3, 5 }
Part[18] = { 2, 4, 7, 8 }
Part[19] = { 1, 3 }
Part[20] = { 2, 4, 6, 7, 8 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
      < Machines >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 3 2 4 7 8 5 6
< Parts >
===== * * * * *
( 1) 2 * 1 1 *
( 2) 8 * 1 1 *
( 3) 9 * 1 1 1 *
( 4) 11 * 1 1 1 *
( 5) 13 * 1 1 1 *
( 6) 14 * 1 1 1 *
( 7) 16 * 1 1 1 *
( 8) 17 * 1 1 1 *
( 9) 19 * 1 1 1 *
===== * = = = = *
(10) 3 * 1 1 1 1 1 *
(11) 4 * 1 1 1 1 1 *
(12) 6 * 1 1 1 1 1 *
(13) 7 * 1 1 1 1 1 *
(14) 18 * 1 1 1 1 1 *
(15) 20 * 1 1 1 1 1 *
===== * = = = = *
(16) 1 * 1 1 *
(17) 5 * 1 1 *
(18) 10 * 1 1 *
(19) 12 * 1 1 *
(20) 15 * 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 3 }
Machine Cell[ 2] = { 2, 4, 7, 8 }
Machine Cell[ 3] = { 5, 6 }
=====
Part Family[ 1] = { 2, 8, 9, 11, 13, 14, 16, 17, 19 }
Part Family[ 2] = { 3, 4, 6, 7, 18, 20 }
Part Family[ 3] = { 1, 5, 10, 12, 15 }
=====

```

< Summary of the performance measures >

```
=====
No. of machines                = 8
No. of part types              = 20
No. of cells                   = 3
Machine cell size              = 4
Total no. of 1's in the original MPIM : |A| = 61
Matrix density                 = 0.381
Total no. of within-block 1's = 52
No. of exceptional elements (EEs) = 9
No. of voids                   = 0
Sum of EEs and voids          = 9
Group Capability Index (GCI)   = 85.25 %
grouping efficiency (GE)       = 95.83 %
Grouping efficacy (GF)        = 85.25 %
Machine utilization (MU)       = 100.00%
No. of redundant machines (RMs) = 0
=====
```

Problem(51) --> Data file name : DB_33_Sandbothe(1998)_20x10.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 2, 3, 4, 6 }
Part[ 2] = { 6, 7, 8, 9, 14 }
Part[ 3] = { 6, 7, 8, 9, 10, 15 }
Part[ 4] = { 7, 8, 9, 10 }
Part[ 5] = { 9, 11, 12 }
Part[ 6] = { 11, 12, 13 }
Part[ 7] = { 11, 12, 13 }
Part[ 8] = { 11, 12, 13 }
Part[ 9] = { 5, 11, 12, 13 }
Part[10] = { 10, 16, 17, 18, 19, 20 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 1 1 1 1 0 1 1 1 0 0 0 0 1 1 1 2
      6 7 8 9 0 4 5 5 1 2 3 1 2 3 4 6 7 8 9 0
< Parts >
===== * * * * *
( 1) 2 * 1 1 1 1 1
( 2) 3 * 1 1 1 1 1 1
( 3) 4 * 1 1 1 1
===== * = = = = =
( 4) 5 * 1 1
( 5) 6 * 1 1 1
( 6) 7 * 1 1 1
( 7) 8 * 1 1 1
( 8) 9 * 1 1 1 1
===== * = = = = =
( 9) 1 * 1 1 1 1
===== * = = = = =
(10)10 * 1 1 1 1 1
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 6, 7, 8, 9, 10, 14, 15 }
Machine Cell[ 2] = { 5, 11, 12, 13 }
Machine Cell[ 3] = { 1, 2, 3, 4 }
Machine Cell[ 4] = { 16, 17, 18, 19, 20 }
=====
Part Family[ 1] = { 2, 3, 4 }
Part Family[ 2] = { 5, 6, 7, 8, 9 }
Part Family[ 3] = { 1 }
Part Family[ 4] = { 10 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 20
No. of part types = 10
No. of cells = 4
Machine cell size = 7
Total no. of 1's in the original MPIM : |A| = 42
Matrix density = 0.21
Total no. of within-block 1's = 39
No. of exceptional elements (EEs) = 3
No. of voids = 11
Sum of EEs and voids = 14
Group Capability Index (GCI) = 92.86 %
grouping efficiency (GE) = 88.00 %
Grouping efficacy (GF) = 73.58 %
Machine utilization (MU) = 78.00 %
No. of redundant machines (RMs) = 0

```


=====

Problem(52) --> Data file name : DB_34_NairNarendran(1999)_8x10.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 2, 3, 6 }
Part[ 2] = { 4, 5, 7, 8 }
Part[ 3] = { 1, 7, 8 }
Part[ 4] = { 4, 5, 6 }
Part[ 5] = { 2, 3, 6 }
Part[ 6] = { 4, 5, 6, 7 }
Part[ 7] = { 2, 3 }
Part[ 8] = { 1, 7, 8 }
Part[ 9] = { 2, 3 }
Part[10] = { 1, 2, 4, 7, 8 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
      < Machines >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      2 3 1 7 8 4 5 6
< Parts >
=====
( 1) 1 * 1 1 *
( 2) 5 * 1 1 *
( 3) 7 * 1 1 *
( 4) 9 * 1 1 *
=====
( 5) 3 * 1 1 1 *
( 6) 8 * 1 1 1 *
( 7)10 * 1 1 1 1 *
=====
( 8) 2 * 1 1 1 1 *
( 9) 4 * 1 1 1 *
(10) 6 * 1 1 1 *
=====
* * * * *

```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 2, 3 }
Machine Cell[ 2] = { 1, 7, 8 }
Machine Cell[ 3] = { 4, 5, 6 }
=====
Part Family[ 1] = { 1, 5, 7, 9 }
Part Family[ 2] = { 3, 8, 10 }
Part Family[ 3] = { 2, 4, 6 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines                = 8
No. of part types              = 10
No. of cells                   = 3
Machine cell size              = 4
Total no. of 1's in the original MPIM : |A| = 32
Matrix density                 = 0.4
Total no. of within-block 1's = 25
No. of exceptional elements (EEs) = 7
No. of voids                  = 1
Sum of EEs and voids          = 8
Group Capability Index (GCI)   = 78.13 %
grouping efficiency (GE)       = 91.60 %
Grouping efficacy (GF)         = 75.76 %
Machine utilization (MU)       = 96.15 %
No. of redundant machines (RMs) = 0
=====
```

Problem(53) --> Data file name : DB_35_IslamSarker(2000)_8x10.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 2, 5, 7 }
Part[ 2] = { 3, 4, 8 }
Part[ 3] = { 1, 6 }
Part[ 4] = { 2, 5, 7 }
Part[ 5] = { 3, 4, 8 }
Part[ 6] = { 2, 5, 7 }
Part[ 7] = { 1, 6 }
Part[ 8] = { 2, 5, 7 }
Part[ 9] = { 3, 4, 8 }
Part[10] = { 2, 3, 7, 8 }
=====
```

< Block Diagonal Solution Matrix >

```

    < Locations >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
    < Machines >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      2 5 7 3 4 8 1 6
< Parts >
===== * * * * *
( 1) 1 * 1 1 1 *
( 2) 4 * 1 1 1 *
( 3) 6 * 1 1 1 *
( 4) 8 * 1 1 1 *
( 5) 10 * 1 1 1 1 *
===== * = = = = *
( 6) 2 * 1 1 1 *
( 7) 5 * 1 1 1 *
( 8) 9 * 1 1 1 *
===== * = = = = *
( 9) 3 * 1 1 *
(10) 7 * 1 1 *
===== * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 2, 5, 7 }
Machine Cell[ 2] = { 3, 4, 8 }
Machine Cell[ 3] = { 1, 6 }
=====
Part Family[ 1] = { 1, 4, 6, 8, 10 }
Part Family[ 2] = { 2, 5, 9 }
Part Family[ 3] = { 3, 7 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 8
No. of part types = 10
No. of cells = 3
Machine cell size = 4
Total no. of 1's in the original MPIM : |A| = 29
Matrix density = 0.362
Total no. of within-block 1's = 27
No. of exceptional elements (EEs) = 2
No. of voids = 1
Sum of EEs and voids = 3
Group Capability Index (GCI) = 93.10 %
grouping efficiency (GE) = 96.29 %
Grouping efficacy (GF) = 90.00 %
Machine utilization (MU) = 96.43 %
No. of redundant machines (RMs) = 0
=====
```

Problem(54) --> Data file name : DB_36_Won(2000)_5x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 2 }
Part[ 2] = { 1, 4 }
Part[ 3] = { 3, 5 }
Part[ 4] = { 2, 4 }
Part[ 5] = { 1, 2 }
Part[ 6] = { 1, 3, 5 }
Part[ 7] = { 1, 4 }
Part[ 8] = { 1, 3, 5 }
Part[ 9] = { 2, 4 }
Part[10] = { 1, 3, 5 }
Part[11] = { 3, 5 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0
      0 0 0 0 0
      1 2 3 4 5
      < Machines >
      0 0 0 0 0
      0 0 0 0 0
      1 2 4 3 5
< Parts >
===== * * * * *
( 1) 1 * 1 1 *
( 2) 2 * 1 1 *
( 3) 4 * 1 1 *
( 4) 5 * 1 1 *
( 5) 7 * 1 1 *
( 6) 9 * 1 1 *
===== * = = = = *
( 7) 3 * 1 1 *
( 8) 6 * 1 1 1 *
( 9) 8 * 1 1 1 *
(10)10 * 1 1 1 *
(11)11 * 1 1 1 *
===== * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 2, 4 }
Machine Cell[ 2] = { 3, 5 }
=====
Part Family[ 1] = { 1, 2, 4, 5, 7, 9 }
Part Family[ 2] = { 3, 6, 8, 10, 11 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 5
No. of part types = 11
No. of cells = 2
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 25
Matrix density = 0.455
Total no. of within-block 1's = 22
No. of exceptional elements (EEs) = 3
No. of voids = 6
Sum of EEs and voids = 9
Group Capability Index (GCI) = 88.00 %
grouping efficiency (GE) = 83.73 %
Grouping efficacy (GF) = 70.97 %
Machine utilization (MU) = 78.57 %
No. of redundant machines (RMs) = 0
=====
```

Problem(55) --> Data file name : DB_37_BrownSumichrast(2001)_6x11.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 5, 6 }
Part[ 2] = { 1, 2 }
Part[ 3] = { 2, 3, 4 }
Part[ 4] = { 1, 4, 6 }
Part[ 5] = { 2, 5 }
Part[ 6] = { 1, 4 }
Part[ 7] = { 2, 6 }
Part[ 8] = { 3 }
Part[ 9] = { 3, 4 }
Part[10] = { 1, 3, 5 }
Part[11] = { 3, 4 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0
      0 0 0 0 0 0
      1 2 3 4 5 6
      < Machines >
      0 0 0 0 0 0
      0 0 0 0 0 0
< Parts >
===== * * * * *
( 1) 3 * 1 1 1 *
( 2) 4 * 1 1 1 *
( 3) 6 * 1 1 *
( 4) 8 * 1 *
( 5) 9 * 1 1 *
( 6) 11 * 1 1 *
===== * = = = = *
( 7) 1 * 1 1 *
( 8) 10 * 1 1 *
===== * = = = = *
( 9) 2 * 1 1 *
(10) 5 * 1 1 *
(11) 7 * 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 3, 4 }
Machine Cell[ 2] = { 5, 6 }
Machine Cell[ 3] = { 1, 2 }
=====
Part Family[ 1] = { 3, 4, 6, 8, 9, 11 }
Part Family[ 2] = { 1, 10 }
Part Family[ 3] = { 2, 5, 7 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 6
No. of part types = 11
No. of cells = 3
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 24
Matrix density = 0.364
Total no. of within-block 1's = 16
No. of exceptional elements (EEs) = 8
No. of voids = 6
Sum of EEs and voids = 14
Group Capability Index (GCI) = 66.67 %
grouping efficiency (GE) = 77.27 %
Grouping efficacy (GF) = 53.33 %
Machine utilization (MU) = 72.73 %
No. of redundant machines (RMs) = 0
=====

```

Problem(56) --> Data file name : DB_38_SarkerKhan(2001)_8x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 2, 4 }
Part[ 2] = { 3, 7 }
Part[ 3] = { 1, 6, 8 }
Part[ 4] = { 2, 3 }
Part[ 5] = { 2, 4, 5, 6 }
Part[ 6] = { 1, 8 }
Part[ 7] = { 6 }
Part[ 8] = { 4, 5 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 2 3 4 5 6 7 8
      < Machines >
      0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0
      1 6 8 2 4 5 3 7
< Parts >
=====
( 1) 3 * 1 1 1 *
( 2) 6 * 1 1 *
( 3) 7 * 1 *
=====
( 4) 1 * 1 1 *
( 5) 4 * 1 1 *
( 6) 5 * 1 1 1 *
( 7) 8 * 1 1 *
=====
( 8) 2 * 1 1 *
=====
* * * * *
=====
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 6, 8 }
Machine Cell[ 2] = { 2, 4, 5 }
Machine Cell[ 3] = { 3, 7 }
=====
Part Family[ 1] = { 3, 6, 7 }
Part Family[ 2] = { 1, 4, 5, 8 }
Part Family[ 3] = { 2 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 8
No. of part types = 8
No. of cells = 3
Machine cell size = 3
Total no. of 1's in the original MPIM : |A| = 18
Matrix density = 0.281
Total no. of within-block 1's = 16
No. of exceptional elements (EES) = 2
No. of voids = 7
Sum of EES and voids = 9
Group Capability Index (GCI) = 88.89 %
grouping efficiency (GE) = 82.34 %
Grouping efficacy (GF) = 64.00 %
Machine utilization (MU) = 69.57 %
No. of redundant machines (RMs) = 0
=====
```

Problem(57) --> Data file name : DB_39_SeifoddiniDjassemi(2001)_Figure_5_36x15.cfp

[illegible][illegible]

Machine Cell	[1]	= { 1, 6, 8, 13, 16, 17, 23, 27, 29, 30, 35 }
Machine Cell	[2]	= { 2, 7, 11, 15, 18, 20, 28, 36 }
Machine Cell	[3]	= { 5, 12, 34 }
Machine Cell	[4]	= { 10, 14, 19, 22, 25, 26, 31, 33 }
Machine Cell	[5]	= { 3, 4, 9, 21, 24, 32 }

< Summary of the performance measures >

No. of machines	= 36
No. of part types	= 15
No. of cells	= 5
Machine cell size	= 11
Total no. of 1's in the original MPIM : $ A $	= 78
Matrix density	= 0.144
Total no. of within-block 1's	= 75
No. of exceptional elements (EEs)	= 3
No. of voids	= 46

Sum of EEs and voids	= 49
Group Capability Index (GCI)	= 96.15 %
grouping efficiency (GE)	= 80.63 %
Grouping efficacy (GF)	= 60.48 %
Machine utilization (MU)	= 61.98 %
No. of redundant machines (RMs)	= 0
=====	

Problem(58) --> Data file name : DB_40_MalakootiYang(2002)_10x15.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 3, 4, 8 }
Part[ 2] = { 1, 6, 7, 9 }
Part[ 3] = { 6, 3, 4, 8, 9 }
Part[ 4] = { 4, 8, 9 }
Part[ 5] = { 2, 10 }
Part[ 6] = { 6, 3, 4, 8, 9 }
Part[ 7] = { 1, 6, 3 }
Part[ 8] = { 5, 10, 3 }
Part[ 9] = { 2, 5, 10 }
Part[10] = { 2, 5, 10 }
Part[11] = { 1, 6, 7 }
Part[12] = { 1, 6, 7, 9 }
Part[13] = { 2, 5, 10, 3 }
Part[14] = { 3, 4, 8, 9 }
Part[15] = { 2, 5, 10 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 1
      1 2 3 4 5 6 7 8 9 0
      < Machines >
      0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 1 0 0 0 0
      1 6 7 2 5 0 3 4 8 9
< Parts >
===== * * * * *
( 1) 2 * 1 1 1 * 1 *
( 2) 7 * 1 1 * 1 *
( 3) 11 * 1 1 1 *
( 4) 12 * 1 1 1 * 1 *
===== * = = = = *
( 5) 5 * 1 1 *
( 6) 8 * 1 1 1 *
( 7) 9 * 1 1 1 *
( 8) 10 * 1 1 1 *
( 9) 13 * 1 1 1 1 *
(10) 15 * 1 1 1 *
===== * = = = = *
(11) 1 * 1 1 1 *
(12) 3 * 1 1 1 1 *
(13) 4 * 1 1 1 *
(14) 6 * 1 1 1 1 *
(15) 14 * 1 1 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 6, 7 }
Machine Cell[ 2] = { 2, 5, 10 }
Machine Cell[ 3] = { 3, 4, 8, 9 }
=====
Part Family[ 1] = { 2, 7, 11, 12 }
Part Family[ 2] = { 5, 8, 9, 10, 13, 15 }
Part Family[ 3] = { 1, 3, 4, 6, 14 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 10
No. of part types = 15
No. of cells = 3
Machine cell size = 4
Total no. of 1's in the original MPIM : |A| = 52
Matrix density = 0.347
Total no. of within-block 1's = 45
No. of exceptional elements (EEs) = 7
No. of voids = 5
Sum of EEs and voids = 12
Group Capability Index (GCI) = 86.54 %
grouping efficiency (GE) = 91.50 %
Grouping efficacy (GF) = 78.95 %
Machine utilization (MU) = 90.00 %
No. of redundant machines (RMs) = 0

```

=====

Problem(59) --> Data file name : DB_41_ZolphagariLiang(2002)_7x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 3, 5, 7 }
Part[ 2] = { 3, 4, 7 }
Part[ 3] = { 2, 6 }
Part[ 4] = { 3, 4 }
Part[ 5] = { 1, 5 }
Part[ 6] = { 2, 6 }
Part[ 7] = { 1, 3, 5, 7 }
Part[ 8] = { 4, 7 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 2 3 4 5 6 7
      < Machines >
      0 0 0 0 0 0 0
      0 0 0 0 0 0 0
      1 3 5 4 7 2 6
< Parts >
=====
* * * * *
( 1) 1 * 1 1 1 1 *
( 2) 5 * 1 1 1 *
( 3) 7 * 1 1 1 1 *
=====
* = = = = *
( 4) 2 * 1 1 1 *
( 5) 4 * 1 1 1 *
( 6) 8 * 1 1 1 *
=====
* = = = = *
( 7) 3 * 1 1 *
( 8) 6 * 1 1 *
=====
* * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 3, 5 }
Machine Cell[ 2] = { 4, 7 }
Machine Cell[ 3] = { 2, 6 }
=====
Part Family[ 1] = { 1, 5, 7 }
Part Family[ 2] = { 2, 4, 8 }
Part Family[ 3] = { 3, 6 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                = 7
No. of part types              = 8
No. of cells                   = 3
Machine cell size              = 3
Total no. of 1's in the original MPIM : |A| = 21
Matrix density                  = 0.375
Total no. of within-block 1's = 17
No. of exceptional elements (EEs) = 4
No. of voids                   = 2
Sum of EEs and voids          = 6
Group Capability Index (GCI)    = 80.95 %
grouping efficiency (GE)       = 89.33 %
Grouping efficacy (GF)         = 73.91 %
Machine utilization (MU)       = 89.47 %
No. of redundant machines (RMs) = 0
=====

```

Problem(60) --> Data file name : DB_42_Mahdavi(2007)_Example_2_10x10.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 2, 3, 9, 10 }
Part[ 2] = { 1, 9, 10 }
Part[ 3] = { 4, 5, 9, 10 }
Part[ 4] = { 6, 7, 8, 9 }
Part[ 5] = { 7, 8 }
Part[ 6] = { 1, 3, 9, 10 }
Part[ 7] = { 4, 9 }
Part[ 8] = { 4, 5, 10 }
Part[ 9] = { 6, 7, 8, 9 }
Part[10] = { 7, 8 }
=====
```

< Block Diagonal Solution Matrix >

```

  < Locations >
    0 0 0 0 0 0 0 0 0 0
    0 0 0 0 0 0 0 0 0 1
    1 2 3 4 5 6 7 8 9 0
  < Machines >
    0 0 0 0 0 0 0 0 0 0
    0 0 0 0 0 0 0 1 0 0
    6 7 8 1 3 4 9 0 2 5
< Parts >
=====
( 1) 4 * 1 1 1      1      *
( 2) 5 * 1 1      *
( 3) 9 * 1 1 1      1      *
( 4)10 * 1 1      *
=====
( 5) 1 *      1 1 1 1 1 *
( 6) 2 *      1 1 1 *
( 7) 3 *      1 1 1 1 *
( 8) 6 *      1 1 1 *
( 9) 7 *      1 1 *
(10) 8 *      1 1 1 *
=====
* = = = = = = = = = *
* * * * * * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 6, 7, 8 }
Machine Cell[ 2] = { 1, 3, 4, 9, 10 }
Machine Cell[ 3] = { 2, 5 } --> Residual cell
=====
```

```
Part Family[ 1] = { 4, 5, 9, 10 }
Part Family[ 2] = { 1, 2, 3, 6, 7, 8 }
Part Family[ 3] --> Empty Part family
=====
```

< Summary of the performance measures >

```
=====
No. of machines                = 10
No. of part types              = 10
No. of cells                   = 3
Machine cell size              = 5
Total no. of 1's in the original MPIM : |A| = 33
Matrix density                  = 0.33
Total no. of within-block 1's = 28
No. of exceptional elements (EEs) = 5
No. of voids                   = 14
Sum of EEs and voids          = 19
Group Capability Index (GCI)    = 84.85 %
grouping efficiency (GE)        = 79.02 %
Grouping efficacy (GF)         = 59.57 %
Machine utilization (MU)        = 66.67 %
No. of redundant machines (RMs) = 2
=====
```

Problem(61) --> Data file name : DB_43_YangYang(2008)_Figure_6b_15x15.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 3, 13 }
Part[ 2] = { 2, 4, 8, 9, 12 }
Part[ 3] = { 2, 3, 4, 8, 9, 12 }
Part[ 4] = { 2, 3, 13, 15 }
Part[ 5] = { 5, 6, 7, 11, 15 }
Part[ 6] = { 5, 6, 7, 10, 11, 15 }
Part[ 7] = { 3, 13 }
Part[ 8] = { 3, 13 }
Part[ 9] = { 2, 4, 8, 9, 12 }
Part[10] = { 1, 10, 14 }
Part[11] = { 3, 13, 14 }
Part[12] = { 1, 8, 10, 14 }
Part[13] = { 2, 4, 8, 9, 12 }
Part[14] = { 5, 6, 7, 11, 12, 15 }
Part[15] = { 1, 10, 11, 14 }
=====
```

< Block Diagonal Solution Matrix >

```

  < Locations >
    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
    0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
    1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
  < Machines >
    0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
    0 1 0 1 1 0 0 0 1 1 0 0 0 0 1
    3 3 1 0 4 5 6 7 1 5 2 4 8 9 2
< Parts >
===== * * * * *
( 1) 1 * 1 1 *
( 2) 4 * 1 1 *
( 3) 7 * 1 1 *
( 4) 8 * 1 1 *
( 5) 11 * 1 1 1 *
===== * = = = = *
( 6) 10 * 1 1 1 *
( 7) 12 * 1 1 1 *
( 8) 15 * 1 1 1 1 *
===== * = = = = *
( 9) 5 * 1 1 1 1 1 *
(10) 6 * 1 1 1 1 1 *
(11) 14 * 1 1 1 1 1 1 *
===== * = = = = *
(12) 2 * 1 1 1 1 1 *
(13) 3 * 1 1 1 1 1 *
(14) 9 * 1 1 1 1 1 *
(15) 13 * 1 1 1 1 1 *
===== * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 3, 13 }
Machine Cell[ 2] = { 1, 10, 14 }
Machine Cell[ 3] = { 5, 6, 7, 11, 15 }
Machine Cell[ 4] = { 2, 4, 8, 9, 12 }
=====
Part Family[ 1] = { 1, 4, 7, 8, 11 }
Part Family[ 2] = { 10, 12, 15 }
Part Family[ 3] = { 5, 6, 14 }
Part Family[ 4] = { 2, 3, 9, 13 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 15
No. of part types = 15
No. of cells = 4
Machine cell size = 5
Total no. of 1's in the original MPIM : |A| = 62
Matrix density = 0.276
Total no. of within-block 1's = 54
No. of exceptional elements (EEs) = 8
No. of voids = 0
Sum of EEs and voids = 8
Group Capability Index (GCI) = 87.10 %
grouping efficiency (GE) = 97.66 %
=====
```

Grouping efficacy (GF)	= 87.10 %
Machine utilization (MU)	= 100.00%
No. of redundant machines (RMs)	= 0

=====

Problem(62) --> Data file name : DB_44_YangYang(2008)_Figure_6d_15x15.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====  
Part[ 1] = { 3, 13 }  
Part[ 2] = { 2, 4, 8, 9 }  
Part[ 3] = { 2, 4, 5, 8, 9, 12 }  
Part[ 4] = { 2, 13, 15 }  
Part[ 5] = { 5, 7, 11, 15 }  
Part[ 6] = { 5, 6, 7, 10, 15 }  
Part[ 7] = { 3, 13 }  
Part[ 8] = { 3, 13 }  
Part[ 9] = { 2, 4, 9, 12 }  
Part[10] = { 1, 10, 14 }  
Part[11] = { 3, 14 }  
Part[12] = { 1, 8, 10, 14 }  
Part[13] = { 4, 8, 9, 12 }  
Part[14] = { 6, 7, 11, 12, 15 }  
Part[15] = { 1, 11, 14 }  
=====
```

< Block Diagonal Solution Matrix >

```
=====  
      < Locations >  
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
      0 0 0 0 0 0 0 0 0 1 1 1 1 1 1  
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5  
      < Machines >  
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
      0 0 0 0 1 0 1 0 0 0 1 1 0 1 1  
      2 4 8 9 2 3 3 5 6 7 1 5 1 0 4  
      < Parts >  
===== * * * * * * * * * * * * * * * *  
( 1) 2 * 1 1 1 1 *  
( 2) 3 * 1 1 1 1 1 1 *  
( 3) 9 * 1 1 1 1 *  
( 4) 13 * 1 1 1 1 *  
===== * = = = = = * = = = = = *  
( 5) 1 * 1 1 *  
( 6) 7 * 1 1 *  
( 7) 8 * 1 1 *  
( 8) 11 * 1 1 *  
===== * = = = = = * = = = = = *  
( 9) 4 * 1 1 1 *  
(10) 5 * 1 1 1 1 *  
(11) 6 * 1 1 1 1 1 *  
(12) 14 * 1 1 1 1 *  
===== * = = = = = * = = = = = *  
(13) 10 * 1 1 1 *  
(14) 12 * 1 1 1 *  
(15) 15 * 1 1 1 *  
===== * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
=====  
Machine Cell[ 1] = { 2, 4, 8, 9, 12 }  
Machine Cell[ 2] = { 3, 13 }  
Machine Cell[ 3] = { 5, 6, 7, 11, 15 }  
Machine Cell[ 4] = { 1, 10, 14 }  
=====  
Part Family[ 1] = { 2, 3, 9, 13 }  
Part Family[ 2] = { 1, 7, 8, 11 }  
Part Family[ 3] = { 4, 5, 6, 14 }  
Part Family[ 4] = { 10, 12, 15 }  
=====
```

< Summary of the performance measures >

```
=====  
No. of machines = 15  
No. of part types = 15  
No. of cells = 4  
Machine cell size = 5  
Total no. of 1's in the original MPIM : |A| = 53  
Matrix density = 0.236  
Total no. of within-block 1's = 45  
No. of exceptional elements (EEs) = 8  
No. of voids = 12  
Sum of EEs and voids = 20  
Group Capability Index (GCI) = 84.91 %  
grouping efficiency (GE) = 87.09 %  
=====
```

Grouping efficacy (GF)	= 69.23 %
Machine utilization (MU)	= 78.95 %
No. of redundant machines (RMs)	= 0

=====

Problem(63) --> Data file name : DB_45_FengPheng(2011)_Matrix_3_11x19.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 2, 4, 6 }
Part[ 2] = { 1, 4, 6, 8 }
Part[ 3] = { 3, 4, 9 }
Part[ 4] = { 3, 4, 9 }
Part[ 5] = { 7, 10, 11 }
Part[ 6] = { 4, 5, 9 }
Part[ 7] = { 3, 4 }
Part[ 8] = { 3, 4 }
Part[ 9] = { 3, 4 }
Part[10] = { 2, 4, 6, 8 }
Part[11] = { 1, 4, 6, 8 }
Part[12] = { 4, 5, 7, 9 }
Part[13] = { 7, 10, 11 }
Part[14] = { 3, 4, 9 }
Part[15] = { 4 }
Part[16] = { 2 }
Part[17] = { 7 }
Part[18] = { 4, 8 }
Part[19] = { 4, 7 }
=====
```

< Block Diagonal Solution Matrix >

```

  < Locations >
    0 0 0 0 0 0 0 0 0 0 0
    0 0 0 0 0 0 0 0 0 1 1
    1 2 3 4 5 6 7 8 9 0 1
  < Machines >
    0 0 0 0 0 0 0 0 0 0 0
    0 0 0 0 0 1 1 0 0 0 0
    3 4 5 9 7 0 1 1 2 6 8
< Parts >
===== * * * * *
( 1) 3 * 1 1 1 *
( 2) 4 * 1 1 1 *
( 3) 6 * 1 1 1 *
( 4) 7 * 1 1 *
( 5) 8 * 1 1 *
( 6) 9 * 1 1 *
( 7) 12 * 1 1 1 1 *
( 8) 14 * 1 1 1 *
( 9) 15 * 1 *
(10) 18 * 1 1 *
(11) 19 * 1 1 *
===== * = = = = *
(12) 5 * 1 1 1 *
(13) 13 * 1 1 1 *
(14) 17 * 1 *
===== * = = = = *
(15) 1 * 1 1 1 *
(16) 2 * 1 1 1 1 *
(17) 10 * 1 1 1 1 *
(18) 11 * 1 1 1 1 *
(19) 16 * 1 *
===== * * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 3, 4, 5, 9 }
Machine Cell[ 2] = { 7, 10, 11 }
Machine Cell[ 3] = { 1, 2, 6, 8 }
=====
Part Family[ 1] = { 3, 4, 6, 7, 8, 9, 12, 14, 15, 18, 19 }
Part Family[ 2] = { 5, 13, 17 }
Part Family[ 3] = { 1, 2, 10, 11, 16 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines                = 11
No. of part types              = 19
No. of cells                   = 3
Machine cell size              = 4
Total no. of 1's in the original MPIM : |A| = 50
Matrix density                 = 0.239
Total no. of within-block 1's = 43
=====
```

No. of exceptional elements (EEs)	= 7
No. of voids	= 30
Sum of EEs and voids	= 37
Group Capability Index (GCI)	= 86.00 %
grouping efficiency (GE)	= 76.88 %
Grouping efficacy (GF)	= 53.75 %
Machine utilization (MU)	= 58.90 %
No. of redundant machines (RMs)	= 0
=====	

Problem(64) --> Data file name : DB_46_Krishnan(2012)_Table_21_15x25.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 5, 9, 12 }
Part[ 2] = { 2, 3, 6, 11 }
Part[ 3] = { 14, 15 }
Part[ 4] = { 3, 11 }
Part[ 5] = { 1, 5, 9, 12 }
Part[ 6] = { 8, 14, 15 }
Part[ 7] = { 8, 15 }
Part[ 8] = { 2, 3, 6 }
Part[ 9] = { 4, 13 }
Part[10] = { 6, 8, 10 }
Part[11] = { 4, 10, 13 }
Part[12] = { 4, 7, 10 }
Part[13] = { 2, 6, 11 }
Part[14] = { 10, 14, 15 }
Part[15] = { 2, 4, 10 }
Part[16] = { 1, 9, 12 }
Part[17] = { 8, 14, 15 }
Part[18] = { 10, 13 }
Part[19] = { 2, 3, 4, 6, 8 }
Part[20] = { 1, 5, 9, 14 }
Part[21] = { 8, 14 }
Part[22] = { 7, 10, 13 }
Part[23] = { 1, 5, 12 }
Part[24] = { 1, 2, 14, 15 }
Part[25] = { 2, 6, 11 }
=====

```

< Block Diagonal Solution Matrix >

```

< Locations >
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5

< Machines >
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 1 1 0 1 1 0 0 0 1
1 5 9 2 4 7 0 3 8 4 5 2 3 6 1

< Parts >
=====
( 1) 1 * 1 1 1 1 *
( 2) 5 * 1 1 1 1 *
( 3) 16 * 1 1 1 1 *
( 4) 20 * 1 1 1 1 *
( 5) 23 * 1 1 1 1 *
=====
( 6) 9 * 1 1 1 1 *
( 7) 10 * 1 1 1 1 *
( 8) 11 * 1 1 1 1 *
( 9) 12 * 1 1 1 1 *
(10) 15 * 1 1 1 1 *
(11) 18 * 1 1 1 1 *
(12) 22 * 1 1 1 1 *
=====
(13) 3 * 1 1 1 1 *
(14) 6 * 1 1 1 1 *
(15) 7 * 1 1 1 1 *
(16) 14 * 1 1 1 1 *
(17) 17 * 1 1 1 1 *
(18) 21 * 1 1 1 1 *
(19) 24 * 1 1 1 1 *
=====
(20) 2 * 1 1 1 1 *
(21) 4 * 1 1 1 1 *
(22) 8 * 1 1 1 1 *
(23) 13 * 1 1 1 1 *
(24) 19 * 1 1 1 1 *
(25) 25 * 1 1 1 1 *
=====
* * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 5, 9, 12 }
Machine Cell[ 2] = { 4, 7, 10, 13 }
Machine Cell[ 3] = { 8, 14, 15 }
Machine Cell[ 4] = { 2, 3, 6, 11 }
=====

```

```
Part Family[ 1] = { 1, 5, 16, 20, 23 }
Part Family[ 2] = { 9, 10, 11, 12, 15, 18, 22 }
Part Family[ 3] = { 3, 6, 7, 14, 17, 21, 24 }
Part Family[ 4] = { 2, 4, 8, 13, 19, 25 }
```

< Summary of the performance measures >

```
No. of machines = 15
No. of part types = 25
No. of cells = 4
Machine cell size = 4
Total no. of 1's in the original MPIM : |A| = 76
Matrix density = 0.203
Total no. of within-block 1's = 67
No. of exceptional elements (EEs) = 9
No. of voids = 26
Sum of EEs and voids = 35
Group Capability Index (GCI) = 88.16 %
grouping efficiency (GE) = 84.43 %
Grouping efficacy (GF) = 65.69 %
Machine utilization (MU) = 72.04 %
No. of redundant machines (RMs) = 0
```

Problem(65) --> Data file name : DB_47_Krishnan(2012)_Table_23_30x30.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 4, 6, 7, 26 }
Part[ 2] = { 5, 8, 18, 27 }
Part[ 3] = { 2, 9, 10 }
Part[ 4] = { 14, 19, 22 }
Part[ 5] = { 9, 10, 29 }
Part[ 6] = { 4, 6, 7 }
Part[ 7] = { 3, 12, 16, 21 }
Part[ 8] = { 23, 30 }
Part[ 9] = { 1, 5, 8, 18, 27 }
Part[10] = { 7, 17, 21, 25 }
Part[11] = { 13, 15, 20 }
Part[12] = { 13, 15, 20, 28 }
Part[13] = { 5, 12, 16, 21 }
Part[14] = { 1, 5, 8, 18 }
Part[15] = { 11, 19, 26 }
Part[16] = { 2, 9, 10, 29 }
Part[17] = { 7, 8, 18, 27 }
Part[18] = { 23, 30 }
Part[19] = { 5, 15, 20 }
Part[20] = { 11, 24, 26 }
Part[21] = { 3, 12, 16, 17, 21 }
Part[22] = { 15, 20, 28 }
Part[23] = { 1, 23, 30 }
Part[24] = { 6, 7, 25 }
Part[25] = { 4, 6, 7, 25 }
Part[26] = { 14, 19 }
Part[27] = { 1, 6, 7, 20, 28 }
Part[28] = { 14, 19, 22 }
Part[29] = { 13, 15, 20 }
Part[30] = { 11, 24, 26 }
=====

```

< Block Diagonal Solution Matrix >

```

< Locations >
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

< Machines >
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 2 0 0 0 0 1 2 0 0 1 2 1 2 0 0 1 1 2 2 0 1 1 2 1 2 2 2 3
1 5 8 8 7 4 6 7 5 4 9 2 2 9 0 9 3 5 0 8 3 2 6 7 1 1 4 6 3 0

< Parts >
=====
( 1) 2 * 1 1 1 1 *
( 2) 9 * 1 1 1 1 1 *
( 3) 14 * 1 1 1 1 *
( 4) 17 * 1 1 1 1 *
=====
( 5) 1 * 1 1 1 *
( 6) 6 * 1 1 1 *
( 7) 24 * 1 1 1 *
( 8) 25 * 1 1 1 1 *
( 9) 27 * 1 1 1 1 *
=====
(10) 4 * 1 1 1 *
(11) 26 * 1 1 1 *
(12) 28 * 1 1 1 *
=====
(13) 3 * 1 1 1 *
(14) 5 * 1 1 1 *
(15) 16 * 1 1 1 1 *
=====
(16) 11 * 1 1 1 *
(17) 12 * 1 1 1 1 *
(18) 19 * 1 1 1 *
(19) 22 * 1 1 1 *
(20) 29 * 1 1 1 *
=====
(21) 7 * 1 1 1 1 *
(22) 10 * 1 1 1 1 *
(23) 13 * 1 1 1 1 *
(24) 21 * 1 1 1 1 *
=====
(25) 15 * 1 1 1 *
(26) 20 * 1 1 1 *
=====

```

```

( 27) 30 *                                     1 1 1 *
===== * = = = = = = = = = = = = = = = = = = = = *
( 28) 8 *                                     1 1 *
( 29) 18 *                                    1 1 *
( 30) 23 * 1                                    1 1 *
===== * * * * * * * * * * * * * * * * * * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 5, 8, 18, 27 }
Machine Cell[ 2] = { 4, 6, 7, 25 }
Machine Cell[ 3] = { 14, 19, 22 }
Machine Cell[ 4] = { 2, 9, 10, 29 }
Machine Cell[ 5] = { 13, 15, 20, 28 }
Machine Cell[ 6] = { 3, 12, 16, 17, 21 }
Machine Cell[ 7] = { 11, 24, 26 }
Machine Cell[ 8] = { 23, 30 }
=====
Part Family[ 1] = { 2, 9, 14, 17 }
Part Family[ 2] = { 1, 6, 24, 25, 27 }
Part Family[ 3] = { 4, 26, 28 }
Part Family[ 4] = { 3, 5, 16 }
Part Family[ 5] = { 11, 12, 19, 22, 29 }
Part Family[ 6] = { 7, 10, 13, 21 }
Part Family[ 7] = { 15, 20, 30 }
Part Family[ 8] = { 8, 18, 23 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines                      = 30
No. of part types                    = 30
No. of cells                         = 8
Machine cell size                    = 5
Total no. of 1's in the original MPIM : |A| = 103
Matrix density                       = 0.114
Total no. of within-block 1's       = 92
No. of exceptional elements (EEs)    = 11
No. of voids                         = 24
Sum of EEs and voids                = 35
Group Cability Index (GCI)           = 89.32 %
grouping efficiency (GE)              = 88.95 %
Grouping efficacy (GF)               = 72.44 %
Machine utilization (MU)              = 79.31 %
No. of redundant machines (RMs)      = 0
=====

```

Problem(66) --> Data file name : DB_48_Noktehdan(2016)_Table_1_11x7.cfp

< Machines visited by parts: Process route numbers(PRN) >

```

=====
Part[ 1] = { 1, 3, 7, 11 }
Part[ 2] = { 1, 2, 6 }
Part[ 3] = { 2, 6, 9 }
Part[ 4] = { 4, 5, 10 }
Part[ 5] = { 3, 7 }
Part[ 6] = { 3, 4, 11 }
Part[ 7] = { 5, 8, 10 }
=====

```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 1 1
      1 2 3 4 5 6 7 8 9 0 1
      < Machines >
      0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 1 0 0 0 1
      1 2 6 9 3 7 1 4 5 8 0
< Parts >
===== * * * * *
( 1) 2 * 1 1 1 *
( 2) 3 * 1 1 1 *
===== * = = = = *
( 3) 1 * 1 1 1 1 *
( 4) 5 * 1 1 *
( 5) 6 * 1 1 1 *
===== * = = = = *
( 6) 4 * 1 1 1 *
( 7) 7 * 1 1 1 *
===== * * * * *

```

< Machine cells and Part families >

```

=====
Machine Cell[ 1] = { 1, 2, 6, 9 }
Machine Cell[ 2] = { 3, 7, 11 }
Machine Cell[ 3] = { 4, 5, 8, 10 }
=====
Part Family[ 1] = { 2, 3 }
Part Family[ 2] = { 1, 5, 6 }
Part Family[ 3] = { 4, 7 }
=====

```

< Summary of the performance measures >

```

=====
No. of machines = 11
No. of part types = 7
No. of cells = 3
Machine cell size = 4
Total no. of 1's in the original MPIM : |A| = 21
Matrix density = 0.273
Total no. of within-block 1's = 19
No. of exceptional elements (EEs) = 2
No. of voids = 6
Sum of EEs and voids = 8
Group Capability Index (GCI) = 90.48 %
grouping efficiency (GE) = 86.08 %
Grouping efficacy (GF) = 70.37 %
Machine utilization (MU) = 76.00 %
No. of redundant machines (RMs) = 0
=====

```

Problem(67) --> Data file name : DB_49_Noktehdan(2016)_Table_7_6x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====
Part[ 1] = { 1, 4, 5, 6 }
Part[ 2] = { 2, 4, 6 }
Part[ 3] = { 1, 3, 5, 6 }
Part[ 4] = { 2, 4, 6 }
Part[ 5] = { 1, 2, 4, 5, 6 }
Part[ 6] = { 1, 5, 6 }
Part[ 7] = { 1, 3, 6 }
Part[ 8] = { 2, 4, 6 }
=====
```

< Block Diagonal Solution Matrix >

```

      < Locations >
      0 0 0 0 0 0
      0 0 0 0 0 0
      1 2 3 4 5 6
      < Machines >
      0 0 0 0 0 0
      0 0 0 0 0 0
      1 3 5 6 2 4
< Parts >
=====
* * * * *
( 1) 1 * 1 1 1 1 *
( 2) 3 * 1 1 1 1 *
( 3) 5 * 1 1 1 1 *
( 4) 6 * 1 1 1 1 *
( 5) 7 * 1 1 1 1 *
=====
* = = = = *
( 6) 2 * 1 1 1 *
( 7) 4 * 1 1 1 *
( 8) 8 * 1 1 1 *
=====
* * * * *
```

< Machine cells and Part families >

```
=====
Machine Cell[ 1] = { 1, 3, 5, 6 }
Machine Cell[ 2] = { 2, 4 }
=====
Part Family[ 1] = { 1, 3, 5, 6, 7 }
Part Family[ 2] = { 2, 4, 8 }
=====
```

< Summary of the performance measures >

```
=====
No. of machines = 6
No. of part types = 8
No. of cells = 2
Machine cell size = 4
Total no. of 1's in the original MPIM : |A| = 28
Matrix density = 0.583
Total no. of within-block 1's = 22
No. of exceptional elements (EEs) = 6
No. of voids = 4
Sum of EEs and voids = 10
Group Capability Index (GCI) = 78.57 %
grouping efficiency (GE) = 78.67 %
Grouping efficacy (GF) = 68.75 %
Machine utilization (MU) = 84.62 %
No. of redundant machines (RMs) = 0
=====
```


Problem(68) --> Data file name : DB_50_Won(2024)_6x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====  
Part[ 1] = { 1, 4 }  
Part[ 2] = { 3, 6 }  
Part[ 3] = { 1 }  
Part[ 4] = { 2, 5 }  
Part[ 5] = { 1, 4 }  
Part[ 6] = { 2, 5 }  
Part[ 7] = { 3, 5, 6 }  
Part[ 8] = { 1, 2 }  
=====
```

< Block Diagonal Solution Matrix >

```
      < Locations >  
      0 0 0 0 0 0  
      0 0 0 0 0 0  
      1 2 3 4 5 6  
      < Machines >  
      0 0 0 0 0 0  
      0 0 0 0 0 0  
      1 4 2 5 3 6  
< Parts >  
===== * * * * * * * *  
( 1) 1 * 1 1 *  
( 2) 3 * 1 *  
( 3) 5 * 1 1 *  
( 4) 8 * 1 1 *  
===== * = = = = = *  
( 5) 4 * 1 1 *  
( 6) 6 * 1 1 *  
===== * = = = = = *  
( 7) 2 * 1 1 *  
( 8) 7 * 1 1 1 *  
===== * * * * * * * *
```

< Machine cells and Part families >

```
=====  
Machine Cell[ 1] = { 1, 4 }  
Machine Cell[ 2] = { 2, 5 }  
Machine Cell[ 3] = { 3, 6 }  
=====  
Part Family[ 1] = { 1, 3, 5, 8 }  
Part Family[ 2] = { 4, 6 }  
Part Family[ 3] = { 2, 7 }  
=====
```

< Summary of the performance measures >

```
=====  
No. of machines = 6  
No. of part types = 8  
No. of cells = 3  
Machine cell size = 2  
Total no. of 1's in the original MPIM : |A| = 16  
Matrix density = 0.333  
Total no. of within-block 1's = 14  
No. of exceptional elements (EEs) = 2  
No. of voids = 2  
Sum of EEs and voids = 4  
Group Capability Index (GCI) = 87.50 %  
grouping efficiency (GE) = 90.63 %  
Grouping efficacy (GF) = 77.78 %  
Machine utilization (MU) = 87.50 %  
No. of redundant machines (RMs) = 0  
=====
```

Problem(69) --> Data file name : DB_51_AskinStandridge(1993)_6x8.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
=====  
Part[ 1] = { 1, 2 }  
Part[ 2] = { 1, 2 }  
Part[ 3] = { 1, 2, 3 }  
Part[ 4] = { 3, 4 }  
Part[ 5] = { 3, 4 }  
Part[ 6] = { 3, 4 }  
Part[ 7] = { 4, 5, 6 }  
Part[ 8] = { 5, 6 }  
=====
```

< Block Diagonal Solution Matrix >

```
      < Locations >  
      0 0 0 0 0 0  
      0 0 0 0 0 0  
      1 2 3 4 5 6  
      < Machines >  
      0 0 0 0 0 0  
      0 0 0 0 0 0  
      1 2 3 4 5 6  
< Parts >  
===== * * * * * * * *  
( 1) 1 * 1 1 *  
( 2) 2 * 1 1 *  
( 3) 3 * 1 1 1 *  
===== * = = = = = *  
( 4) 4 * 1 1 *  
( 5) 5 * 1 1 *  
( 6) 6 * 1 1 *  
===== * = = = = = *  
( 7) 7 * 1 1 1 *  
( 8) 8 * 1 1 *  
===== * * * * * * * *
```

< Machine cells and Part families >

```
=====  
Machine Cell[ 1] = { 1, 2 }  
Machine Cell[ 2] = { 3, 4 }  
Machine Cell[ 3] = { 5, 6 }  
=====
```

```
Part Family[ 1] = { 1, 2, 3 }  
Part Family[ 2] = { 4, 5, 6 }  
Part Family[ 3] = { 7, 8 }  
=====
```

< Summary of the performance measures >

```
=====  
No. of machines = 6  
No. of part types = 8  
No. of cells = 3  
Machine cell size = 2  
Total no. of 1's in the original MPIM : |A| = 18  
Matrix density = 0.375  
Total no. of within-block 1's = 16  
No. of exceptional elements (EEs) = 2  
No. of voids = 0  
Sum of EEs and voids = 2  
Group Capability Index (GCI) = 88.89 %  
grouping efficiency (GE) = 96.88 %  
Grouping efficacy (GF) = 88.89 %  
Machine utilization (MU) = 100.00%  
No. of redundant machines (RMs) = 0  
=====
```