CMSS

A Computer Manpower Scheduling System (CMSS) Users Manual

Prepared by
Richard J. Giglio
Phillip Chong
Department of Industrial Engineering
and Operations Research
University of Massachusetts at Amherst

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A COMPUTER MANPOWER SCHEDULING SYSTEM (CMSS)

USER'S MANUAL

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I. Introduction

The Computer Manpower Scheduling System (CMSS) is designed to schedule employees to different shift and days-off patterns when the demand for services and hence the minimum employee requirements, fluctuate from hour to hour and day to day.

A shift pattern (or shift) is simply a set of hours which an employee is expected to work. For example, 8 a.m. to 5 p.m. or 12 noon to 4 p.m. Full-time shifts are normally defined to be eight hours, part-time shifts are anything less than eight hours. A contiguous shift is one in which there is no break specifically scheduled (this is often the case in the food service industry). A split shift is one in which there is an hour or more between the assigned working hours for the employee, eg., 9-12 and 2-6. Typical operations requiring manpower scheduling of the type described above include service operations like telephone directory assistance, turnpike toll collection, and food service operations.

AMSS essentially consists of two computer programs written in FORTRAN IV.

1. SCHED develops the optimal employee schedule for a day, given that the minimum manpower requirements fluctuate from hour to hour.
2. MANPOW develops the optimal employee schedule for a week, given that the minimum manpower requirements fluctuate from hour to hour and day to day. Also, MANPOW insures that employees receive two consecutive days off each week.

The manual is divided into two sections. The first section is devoted to explaining the detailed conditions under which the employees are scheduled in SCHED along with instructions on how to use the program. A sample problem including its output is provided. Similarly, the second section is devoted to explaining how and when to use the program MANPOW.

Cont.

A sample problem is again provided.

Both programs SCHED and MANPOW use an integer program code as one of their subroutines. References to the algorithms used in SCHED and MANPOW can be found in [1] and [2].

II. Program SCHED

SCHED develops an optimal employee schedule for a day consistent with the following conditions:

1. The objective is to minimize the cost of employees.
2. The hour-by-hour manpower requirements for the day must be met.
3. The user shall specify the shift patterns and the cost of an employee working in the shifts.
4. Only one break is allowed for split shifts. The break can be as long as the user desires.
5. The number of working hours in the working day can be up to 24 hours.
6. As many as forty shift patterns (both contiguous and split) can be specified.

SCHED INPUT DATA FILE

To use SCHED, the user shall create an input data file called TAPE1 which consists of the following:

1. The first line of data consists of one integer, M, indicating the number of working hours in the day concerned.
2. The second line must contain in order and separated by commas, the M values of the minimum manpower requirements for each hour.
3. The third line consists of one integer NC, indicating the number of contiguous shift patterns.
4. The next NC lines contain in order, the beginning hour, ending hour (inclusive) of the contiguous shift, and the cost of an

employee working in the shift. (Use the cost for the entire shift--ie., hourly rate times number of hours) All numbers are separated by commas.

5. The next line consists of one integer, NS, indicating the number of split shift patterns.
6. The next NS lines contain in order, the beginning and ending hour (inclusive) of the first half of the split shift, followed by the beginning and ending hour of the second half of the shift, and cost of an employee working in that shift. All numbers are separated by commas.

EXHIBIT 1

DATA FOR SCHED SAMPLE PROBLEM

Number of working hours = 10

Minimum manpower requirements for each of the 10 hours = (8,8,8,11,7,12,7,6,4,4)

Number of contiguous shift patterns = 7

Shift 1 starts at hour 1 goes through hour 8. Cost = 8

Shift 2 starts at hour 2 goes through hour 6. Cost = 5

Shift 3 starts at hour 4 goes through hour 10. Cost = 7

Shift 4 starts at hour 6 goes through hour 9. Cost = 4

Shift 5 starts at hour 1 goes through hour 3. Cost = 3

Shift 6 starts at hour 2 goes through hour 7. Cost = 6

Shift 7 starts at hour 3 goes through hour 8. Cost = 6.

Number of split shifts = 7

Split shift 8 from hours 1-4 and 6-9. Cost = 8

Split shift 9 from hours 2-4 and 6-8. Cost = 6

Split shift 10 from hours 1-3 and 5-7. Cost = 6

Split shift 11 from hours 1-2 and 5-8. Cost = 6

Split shift 12 from hours 1-4 and 6-6. Cost = 5

Split shift 13 from hours 2-4 and 7-10. Cost = 7

Split shift 14 from hours 5-6 and 9-10. Cost = 4

EXHIBIT 2

PROGRAM SCHED

LISTING OF DATA FILE

FOR EXAMPLE PROBLEM 1.

```
10
8,8,8,11,7,12,7,6,4,4
7
1,8,8
2,6,5
4,10,7
6,9,4
1,3,3
2,7,6
3,8,6
7
1,4,6,9,8
2,4,6,8,6
1,3,5,7,6
1,2,5,8,6
1,4,6,6,5
2,4,7,10,7
5,6,9,10,4
```

EXHIBIT 3

PROGRAM SCHED

LISTING OF OUTPUT FROM EXAMPLE

PROBLEM 1

CONTINUOUS SHIFTS

FROM HOUR	1	TO HOUR	8	? OF WORKERS	2
FROM HOUR	2	TO HOUR	6	? OF WORKERS	0
FROM HOUR	4	TO HOUR	10	? OF WORKERS	4
FROM HOUR	6	TO HOUR	9	? OF WORKERS	0
FROM HOUR	1	TO HOUR	3	? OF WORKERS	0
FROM HOUR	2	TO HOUR	7	? OF WORKERS	0
FROM HOUR	3	TO HOUR	8	? OF WORKERS	0

SPLIT SHIFTS

FROM HOUR	1	TO HOUR	4	FROM HOUR	6	TO HOUR	9	? OF WORKERS	0
FROM HOUR	2	TO HOUR	4	FROM HOUR	6	TO HOUR	8	? OF WORKERS	0
FROM HOUR	1	TO HOUR	3	FROM HOUR	5	TO HOUR	7	? OF WORKERS	1
FROM HOUR	1	TO HOUR	2	FROM HOUR	5	TO HOUR	8	? OF WORKERS	0
FROM HOUR	1	TO HOUR	4	FROM HOUR	6	TO HOUR	6	? OF WORKERS	5
FROM HOUR	2	TO HOUR	4	FROM HOUR	7	TO HOUR	10	? OF WORKERS	0
FROM HOUR	5	TO HOUR	6	FROM HOUR	9	TO HOUR	10	? OF WORKERS	0

SUMMARY

HOURS	1	2	3	4	5	6	7	8	9	10
MEN ON DUTY	8.0	8.0	8.0	11.0	7.0	12.0	7.0	6.0	4.0	4.0
MEN REQUIRED	8.0	8.0	8.0	11.0	7.0	12.0	7.0	6.0	4.0	4.0
EXCESS MEN	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

III. Program MANPOW

MANPOW develops an optimal employee schedule for a week cycle consistent with the following conditions:

1. The objective is to minimize the cost of employees.
2. The scheduled hour-by-hour manpower requirements for each day of the week cycle must be met.
3. Each employee works five consecutive days and is given two consecutive days off per week.
4. Each hour has at least one full time employee on duty.
5. An employee can work one shift on one day and another shift on another day.
6. The number of hours in each working day is greater than eight hours but no longer than sixteen hours; the latter condition is specified so that every employee is given at least eight hours break before working again.
7. A full time shift is a shift of eight hours work, either contiguous or split. A split shift must not allow more than a maximum of four hours break.
8. A part time shift is a shift of four hours work, either contiguous or split. A split shift must not allow more than a maximum of four hours break.
9. A full time employee is one who works only in full time shifts. Similarly, a part time employee is one who works only in part time shifts.
10. Except for the last seven hours of any working day, there exists one full time contiguous shift beginning at every hour. Similarly, except for the last three hours of any working day, there exists one part time contiguous shift beginning at every hour. These

contiguous shifts are built into the model. However, the user can eliminate those built-in shifts which are undesirable. The user shall specify any desirable full time or part time split shifts. However, one must be careful that there is enough flexibility in shift patterns or else no assignment of manpower would be able to meet the demand. In the unlikely event that the algorithm has to schedule an undesirable shift to make an efficient schedule the computer program will print out an appropriate message.

11. The cost of an employee depends whether s/he is a full time or a part time employee and does not depend on the shifts s/he is assigned to on each day. The cost of each full time employee is the same and the cost of each part time employee is also the same. The cost of one full time employee is assumed to be slightly less than the cost of two part time employees. Or alternatively, the employer would prefer one full time employee to two part time employees.

WORK SHIFT FORM

To assist the user to code up the data, the following form (Exhibit 4) can be used. This form is designed to help the planner visualize the shifts which are available for the scheduling algorithm. A number of standard full time and part time shifts are included on the data sheet and are automatically included in the scheduling program. However, the user can delete any or all of them as described below. Also, the user can add shifts using the blank columns in the data sheet. One must be careful to insure that the final set of shifts covers all the hours when manpower is needed.

The number of hours is sixteen, but if a user is planning for a shorter day he need only specify zero requirements for the extra hours or design a similar sheet with fewer number of hours. No change need to be made to the computer program because the number of working hours per day is input data and so the program automatically takes day-length into consideration.

MANPOW INPUT DATA FILE

The user can rely on the worksheet of Exhibit 4 to prepare input data for the program. To do this he must create an input data file called TAPE1, which consists of the following: (again, all numbers are separated by commas)

1. The first line consists of one integer NH, indicating the number of working hours in day 1.
2. The second line consists of two integers, NSFT and NSPT, indicating the number of user specified (ie., non-standard) full-time split shifts and the number of user specified part-time shifts.
3. The next NSFT lines consist of four integers indicating the beginning and ending hours of the first and second halves of the full time split shifts, in order, from the first to NSFT shift.
4. The next NSPT lines consist of four integers, indicating the beginning and ending hours of the first and second halves of the part time split shifts, in order, from the first shift to the NSPT shift.
5. The next line contains an integer, NUD. If NUD is 0, indicates that none of the built-in continuous shifts are undesirable. Otherwise, NUD is the number of undesirable built-in shifts.
6. If NUD is 0, this line is omitted. Otherwise, the next NUD lines contain in order, the shift numbers (integer) which are

EXHIBIT 4 WORKSHEET

1. Day #(s)*
2. On table below fill in the following:
   a. Mark X for undesirable shift pattern
   b. Add on any 8 or 4 hour split shift pattern
   c. Specify hour by hour manpower requirement beginning from start of work day

SHIFT PATTERNS+

Hour	Full time									2b	Part time													2b	2c Requirements
1	1	0	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0	0		
2	1	1	0	0	0	0	0	0	0		1	1	0	0	0	0	0	0	0	0	0	0	0		
3	1	1	1	0	0	0	0	0	0		1	1	1	0	0	0	0	0	0	0	0	0	0		
4	1	1	1	1	0	0	0	0	0		1	1	1	1	0	0	0	0	0	0	0	0	0		
5	1	1	1	1	1	0	0	0	0		0	1	1	1	1	0	0	0	0	0	0	0	0		
6	1	1	1	1	1	1	0	0	0		0	0	1	1	1	1	0	0	0	0	0	0	0		
7	1	1	1	1	1	1	1	0	0		0	0	0	1	1	1	1	0	0	0	0	0	0		
8	1	1	1	1	1	1	1	1	0		0	0	0	0	1	1	1	1	0	0	0	0	0		
9	0	1	1	1	1	1	1	1	1		0	0	0	0	0	1	1	1	1	0	0	0	0		
10	0	0	1	1	1	1	1	1	1		0	0	0	0	0	0	1	1	1	1	0	0	0		
11	0	0	0	1	1	1	1	1	1		0	0	0	0	0	0	0	1	1	1	1	0	0		
12	0	0	0	0	1	1	1	1	1		0	0	0	0	0	0	0	0	1	1	1	1	0		
13	0	0	0	0	0	1	1	1	1		0	0	0	0	0	0	0	0	0	1	1	1	1		
14	0	0	0	0	0	0	1	1	1		0	0	0	0	0	0	0	0	0	0	1	1	1		
15	0	0	0	0	0	0	0	1	1		0	0	0	0	0	0	0	0	0	0	0	1	1		
16	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1		
2a Undesirable Shift Pattern																									
Shift Number																									

*Use 1 for Mon., 2 for Tues., 3 for Wed., and so on; if Mon. and Tues. have identical requirements write 1,2.

+1 in shift pattern designates employee on duty
0 in shift pattern designates employee off duty

undesirable. Note that all shifts are numbered sequentially on the Work-Shift Form (Exhibit 4). Thus, the identification number of the standard part-time shifts will depend on how many non-standard split shifts have been specified by the user.

7. The next line contains NH real numbers, indicating the minimum manpower requirements for each hour of the day.
8. The data for the next 6 days will be entered in the same way from step 1 to 7.

SAMPLE PROBLEM

A sample problem is provided below in Exhibits 5 through 8.

EXHIBIT 5

SAMPLE PROBLEM FOR MANPOW

EXAMPLE PROBLEM 2

Suppose the following data are for day 1, Monday.

- Number of working hours in the day: 10.
- The user wishes to specify two full time split shifts
  - hours 1 through 3, 6 through 10
  - hours 1 through 4, 7 through 10
- The user wishes to specify four part time split shifts
  - hours 1 through 2, 7 through 8
  - hours 3 through 4, 6 through 7
  - hours 4 through 6, 8 through 8
  - hours 3 through 5, 9 through 9
- The user does not wish to include the standard shifts:
  - hours 2 through 9
  - hours 4 through 7
- The manpower requirements for hours 1 through 10 are 3,4,4,6,5

4,6,5,3,2 respectively.

- The data forms would be as in Exhibit 6. In preparing the sample data file we have also assumed that the shift pattern for days 2-5 are the same as Monday in the example, Saturday and Sunday slightly differ. The user, of course, could specify different patterns for each day.

EXHIBIT 6 WORKSHEET FOR EXAMPLE PROBLEM 2

1. Day #(s)*: Mon-Fri 1-5
2. On the table below fill in the following:
   a. Mark X for undesirable shift pattern
   b. Add on an 8 or 4 hour split shift pattern
   c. Specify hour by hour manpower requirement beginning from start of working day

SHIFT PATTERNS+

Hour	Full Time				2b		Part Time							2b				2c Requirements
1	1	0	0		1	1	1	0	0	0	0	0	0	1	0	0	0	3
2	1	1	0		1	1	1	1	0	0	0	0	0	1	0	0	0	4
3	1	1	1		1	1	1	1	1	0	0	0	0	0	1	0	1	4
4	1	1	1		0	1	1	1	1	1	0	0	0	0	1	1	1	6
5	1	1	1		0	0	0	1	1	1	1	0	0	0	0	1	1	5
6	1	1	1		1	0	0	0	1	1	1	1	0	0	1	1	0	4
7	1	1	1		1	1	0	0	0	1	1	1	1	1	1	0	0	6
8	1	1	1		1	1	0	0	0	0	1	1	1	1	0	1	0	5
9	0	1	1		1	1	0	0	0	0	0	1	1	0	0	0	1	3
10	0	0	0		1	1	0	0	0	0	0	0	1	0	0	0	0	2
a Undesirable Shift Patterns		X								X								
hift Numbers	1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16	

*Use 1 for Mon., 2 for Tues., 3 for Wed., and so on; if Mon. and Tues. have identical requirements, write 1, 2.

+1 in shift pattern designates employee on duty
0 in shift pattern designates employee off duty

EXHIBIT 6 WORKSHEET FOR EXAMPLE PROBLEM 2 (CONT.)

1. Day #(s)*: Sat-Sun 6,7

2. On the table below fill in the following:
   a. Mark X for undesirable shift pattern
   b. Add on an 8 or 4 hour split shift pattern
   c. Specify hour by hour manpower requirement beginning from start of working day

SHIFT PATTERNS+

Hour	Full Time					2b			Part Time									2b				2c Requirements
1	1	0	0	0	0	1	1		1	0	0	0	0	0	0	0	0	1	0	0	0	1
2	1	1	0	0	0	1	1		1	1	0	0	0	0	0	0	0	1	0	0	0	2
3	1	1	1	0	0	1	1		1	1	1	0	0	0	0	0	0	0	1	0	1	2
4	1	1	1	1	0	0	1		1	1	1	1	0	0	0	0	0	0	1	1	1	3
5	1	1	1	1	1	0	0		0	1	1	1	1	0	0	0	0	0	0	1	1	1
6	1	1	1	1	1	1	0		0	0	1	1	1	1	0	0	0	0	1	1	0	2
7	1	1	1	1	1	1	1		0	0	0	1	1	1	1	0	0	1	1	0	0	2
8	1	1	1	1	1	1	1		0	0	0	0	1	1	1	1	0	1	0	1	0	1
9	0	1	1	1	1	1	1		0	0	0	0	0	1	1	1	1	0	0	0	1	3
10	0	0	1	1	1	1	1		0	0	0	0	0	0	1	1	1	0	0	0	0	2
11	0	0	0	1	1	0	0		0	0	0	0	0	0	0	1	1	0	0	0	0	2
12	0	0	0	0	1	0	0		0	0	0	0	0	0	0	0	1	0	0	0	0	1
2a Undesirable shift patterns		X								X												
Shift number	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15	16	17	18	19	20	

*Use 1 for Monday, 2 for Tues., 3 for Wed., and so on; if Mon. and Tues. have identical requirements write 1,2.

+1 in shift pattern designates employee on duty
0 in shift pattern designates employee off duty

EXHIBIT 7

PROGRAM MANPOW

LISTING OF

DATA FILE FOR EXAMPLE

PROBLEM 2

```
10
2,4
1,3,6,10
1,4,7,10
1,2,7,8
3,4,6,7
4,6,8,8
3,5,9,9
2
2
9
3,4,4,6,5,4,4,5,3,2
10
2,4
1,3,6,10
1,4,7,10
1,2,7,8
3,4,6,7
4,6,8,8
3,5,9,9
2
2
9
3,4,4,6,5,4,4,5,3,2
10
2,4
1,3,6,10
1,4,7,10
1,2,7,8
3,4,6,7
4,6,8,8
3,5,9,9
2
2
9
```

EXHIBIT 7 CONT.

```
3,4,4,6,5,4,4,5,3,2
10
2,4
1,3,6,10
1,4,7,10
1,2,7,8
3,4,6,7
4,6,8,8
3,5,9,9
2
2
9
3,4,4,6,5,4,4,5,3,2
10
2,4
1,3,6,10
1,4,7,10
1,2,7,8
3,4,6,7
4,6,8,8
3,5,9,9
2
2
9
3,4,4,6,5,4,4,5,3,2
12
2,4
1,3,6,10
1,4,7,10
1,2,7,8
3,4,6,7
4,6,8,8
3,5,9,9
2
2
9
1,2,2,3,1,2,2,1,3,2,2,1
12
2,4
1,3,6,10
1,4,7,10
1,2,7,8
3,4,6,7
4,6,8,8
3,5,9,9
2
2
9
1,2,2,3,1,2,2,1,3,2,2,1
```

EXHIBIT 8 PROGRAM MANPOW LISTING OF OUTPUT FROM EXAMPLE PROBLEM 2

DAY NUMBER 1

HOURS		1	2	3	4	5	6	7	8	9	10
FULL TIME EMPLOYEES											
MAN NUMBER	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	4	0.	0.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MAN NUMBER	5	1.0	1.0	1.0	1.0	0.	0.	1.0	1.0	1.0	1.0
PART TIME EMPLOYEES											
MAN NUMBER	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	2	0.	0.	1.0	1.0	1.0	0.	0.	0.	1.0	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.
MAN NUMBER	4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MEN ON DUTY		5.0	5.0	7.0	7.0	5.0	4.0	5.0	5.0	3.0	2.0
MEN REQUIRED		3.0	4.0	4.0	6.0	5.0	4.0	4.0	5.0	3.0	2.0
EXCESS MEN		2.0	1.0	3.0	1.0	0.	0.	1.0	0.	0.	0.

DAY NUMBER 2

HOURS		1	2	3	4	5	6	7	8	9	10
FULL TIME EMPLOYEES											
MAN NUMBER	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	5	0.	0.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PART TIME EMPLOYEES											
MAN NUMBER	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	2	0.	0.	1.0	1.0	1.0	0.	0.	0.	1.0	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.
MAN NUMBER	4	0.	0.	0.	0.	0.	0.	1.0	1.0	1.0	1.0
MEN ON DUTY		4.0	4.0	6.0	6.0	5.0	4.0	5.0	5.0	3.0	2.0
MEN REQUIRED		3.0	4.0	4.0	6.0	5.0	4.0	4.0	5.0	3.0	2.0
EXCESS MEN		1.0	0.	2.0	0.	0.	0.	1.0	0.	0.	0.

EXHIBIT 8 CONT.

DAY NUMBER 3

HOURS		1	2	3	4	5	6	7	8	9	10
FULL TIME EMPLOYEES											
MAN NUMBER	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	5	0.	0.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PART TIME EMPLOYEES											
MAN NUMBER	1	0.	0.	1.0	1.0	1.0	0.	0.	0.	1.0	0.
MAN NUMBER	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.
MAN NUMBER	4	0.	0.	0.	0.	0.	0.	1.0	1.0	1.0	1.0
MEN ON DUTY		4.0	4.0	6.0	6.0	5.0	4.0	5.0	5.0	3.0	2.0
MEN REQUIRED		3.0	4.0	4.0	6.0	5.0	4.0	4.0	5.0	3.0	2.0
EXCESS MEN		1.0	0.	2.0	0.	0.	0.	1.0	0.	0.	0.

DAY NUMBER 4

HOURS		1	2	3	4	5	6	7	8	9	10
FULL TIME EMPLOYEES											
MAN NUMBER	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	5	0.	0.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PART TIME EMPLOYEES											
MAN NUMBER	1	0.	0.	1.0	1.0	1.0	0.	0.	0.	1.0	0.
MAN NUMBER	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.
MAN NUMBER	4	0.	0.	0.	0.	0.	0.	1.0	1.0	1.0	1.0
MEN ON DUTY		4.0	4.0	6.0	6.0	5.0	4.0	5.0	5.0	3.0	2.0
MEN REQUIRED		3.0	4.0	4.0	6.0	5.0	4.0	4.0	5.0	3.0	2.0
EXCESS MEN		1.0	0.	2.0	0.	0.	0.	1.0	0.	0.	0.

EXHIBIT 8 CONT.

DAY NUMBER 5

HOURS		1	2	3	4	5	6	7	8	9	10
FULL TIME EMPLOYEES											
MAN NUMBER	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.
MAN NUMBER	5	0.	0.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PART TIME EMPLOYEES											
MAN NUMBER	1	0.	0.	1.0	1.0	1.0	0.	0.	0.	1.0	0.
MAN NUMBER	2	1.0	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.
MAN NUMBER	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	4	0.	0.	0.	0.	0.	0.	1.0	1.0	1.0	1.0
MEN ON DUTY		4.0	4.0	6.0	6.0	5.0	4.0	5.0	5.0	3.0	2.0
MEN REQUIRED		3.0	4.0	4.0	6.0	5.0	4.0	4.0	5.0	3.0	2.0
EXCESS MEN		1.0	0.	2.0	0.	0.	0.	1.0	0.	0.	0.

DAY NUMBER 6

HOURS		1	2	3	4	5	6	7	8	9	10	11	12
FULL TIME EMPLOYEES													
MAN NUMBER	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.	0.	0.
MAN NUMBER	2	0.	0.	0.	0.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MAN NUMBER	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PART TIME EMPLOYEES													
MAN NUMBER	1	1.0	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	2	0.	0.	0.	0.	0.	0.	0.	0.	1.0	1.0	1.0	1.0
MAN NUMBER	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER	4	0.	0.	1.0	1.0	1.0	0.	0.	0.	1.0	0.	0.	0.
MEN ON DUTY		2.0	2.0	3.0	3.0	3.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0
MEN REQUIRED		1.0	2.0	2.0	3.0	1.0	2.0	2.0	1.0	3.0	2.0	2.0	1.0
EXCESS MEN		1.0	0.	1.0	0.	2.0	0.	0.	1.0	0.	0.	0.	1.0

EXHIBIT 8 CONT.

DAY NUMBER 7

HOURS	1	2	3	4	5	6	7	8	9	10	11	12
FULL TIME EMPLOYEES												
MAN NUMBER 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.	0.	0.	0.
MAN NUMBER 2	0.	0.	0.	0.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MAN NUMBER 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER 5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PART TIME EMPLOYEES												
MAN NUMBER 1	1.0	1.0	1.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.
MAN NUMBER 2	0.	0.	0.	0.	0.	0.	0.	0.	1.0	1.0	1.0	1.0
MAN NUMBER 3	0.	0.	1.0	1.0	1.0	0.	0.	0.	1.0	0.	0.	0.
MAN NUMBER 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MEN ON DUTY	2.0	2.0	3.0	3.0	3.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0
MEN REQUIRED	1.0	2.0	2.0	3.0	1.0	2.0	2.0	1.0	3.0	2.0	2.0	1.0
EXCESS MEN	1.0	0.	1.0	0.	2.0	0.	0.	1.0	0.	0.	0.	1.0

TOTAL MAN HOURS WORKED 280

TOTAL MAN HOURS REQUIRED 244

TOTAL EXCESS MAN HOURS 36

EXHIBIT 8 CONT.

SUMMARY

FULL TIME EMPLOYEES

```
WORKER  ?     1
DAY  ?        1     FROM HOUR     1     TO HOUR     8
DAY  ?        4     FROM HOUR     1     TO HOUR     8
DAY  ?        5     FROM HOUR     1     TO HOUR     8
DAY  ?        6     FROM HOUR     1     TO HOUR     8
DAY  ?        7     FROM HOUR     1     TO HOUR     8

WORKER  ?     2
DAY  ?        1     FROM HOUR     1     TO HOUR     8
DAY  ?        2     FROM HOUR     1     TO HOUR     8
DAY  ?        3     FROM HOUR     1     TO HOUR     8
DAY  ?        6     FROM HOUR     5     TO HOUR    12
DAY  ?        7     FROM HOUR     5     TO HOUR    12

WORKER  ?     3
DAY  ?        1     FROM HOUR     1     TO HOUR     8
DAY  ?        2     FROM HOUR     1     TO HOUR     8
DAY  ?        3     FROM HOUR     1     TO HOUR     8
DAY  ?        4     FROM HOUR     1     TO HOUR     8
DAY  ?        5     FROM HOUR     1     TO HOUR     8

WORKER  ?     4
DAY  ?        1     FROM HOUR     3     TO HOUR    10
DAY  ?        2     FROM HOUR     1     TO HOUR     8
DAY  ?        3     FROM HOUR     1     TO HOUR     8
DAY  ?        4     FROM HOUR     1     TO HOUR     8
DAY  ?        5     FROM HOUR     1     TO HOUR     8

WORKER  ?     5
DAY  ?        1     FROM HOUR     1     TO HOUR     4     FROM HOUR     7     TO HOUR    10
DAY  ?        2     FROM HOUR     3     TO HOUR    10
DAY  ?        3     FROM HOUR     3     TO HOUR    10
DAY  ?        4     FROM HOUR     3     TO HOUR    10
DAY  ?        5     FROM HOUR     3     TO HOUR    10
```

EXHIBIT 8 CONT.

PART TIME EMPLOYEES

```
WORKER  ?     1
DAY  ?     3     FROM HOUR     3     TO HOUR     5     FROM HOUR     9     TO HOUR     9
DAY  ?     4     FROM HOUR     3     TO HOUR     5     FROM HOUR     9     TO HOUR     9
DAY  ?     5     FROM HOUR     3     TO HOUR     5     FROM HOUR     9     TO HOUR     9
DAY  ?     6     FROM HOUR     1     TO HOUR     4
DAY  ?     7     FROM HOUR     1     TO HOUR     4

WORKER  ?     2
DAY  ?     1     FROM HOUR     3     TO HOUR     5     FROM HOUR     9     TO HOUR     9
DAY  ?     2     FROM HOUR     3     TO HOUR     5     FROM HOUR     9     TO HOUR     9
DAY  ?     5     FROM HOUR     1     TO HOUR     4
DAY  ?     6     FROM HOUR     9     TO HOUR     12
DAY  ?     7     FROM HOUR     9     TO HOUR     12

WORKER  ?     3
DAY  ?     1     FROM HOUR     1     TO HOUR     4
DAY  ?     2     FROM HOUR     1     TO HOUR     4
DAY  ?     3     FROM HOUR     1     TO HOUR     4
DAY  ?     4     FROM HOUR     1     TO HOUR     4
DAY  ?     7     FROM HOUR     3     TO HOUR     5     FROM HOUR     9     TO HOUR     9

WORKER  ?     4
DAY  ?     2     FROM HOUR     7     TO HOUR     10
DAY  ?     3     FROM HOUR     7     TO HOUR     10
DAY  ?     4     FROM HOUR     7     TO HOUR     10
DAY  ?     5     FROM HOUR     7     TO HOUR     10
DAY  ?     6     FROM HOUR     3     TO HOUR     5     FROM HOUR     9     TO HOUR     9
```

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