# CUMCM-2004 Problems

*(Note: University-level teams can choose any one from problems A and B; College-level teams can choose any one from problems C and D)*

## Problem A: Planning Temporary Mini Supermarkets for the Olympic Games

*Acknowledgements: Thanks to the Beijing Municipal Administer Committee and the Beijing City Planning Committee for provision of the stadium planning figure.*

The construction work of Beijing 2008 Olympic Games has been in planning and implementation processes. During the Olympic Games, temporary Mini Supermarkets should be built around the stadium for supplying food, souvenir and tourist commodities to the spectators, tourists and members of staff, each Mini Supermarket (MS) consisting of variety shops. For MS around the stadium, their location, size and the amount of sales should satisfy three basic requirements: demand for shopping, reasonable distribution and commercial profit during the Games.

The planning layout of the main stadiums for contest is shown in Fig. 1. For simplicity we only remain in Fig. 2 the related parts and regions, such as streets (white denote pavement), bus and taxi stops, parking area, subway stations and restaurants etc., where the yellow area marked with A1-A10, B1-B6 and C1-C4 denote the prescribed 20 shopping centers consisting of the MS.

One way to find the patterns of the consumer flux is to send out questionnaire forms to the spectators, they are the principle consumers during the preview games for investigating purchase demand and appetite of tour. Suppose that three games had been held in a ready stadium (Fig.3) and related data are collected and is shown in the Appendix (please download from http://2004.mcm.edu.cn/problems2004e.htm).

Your team is asked to be a consultant for planning MS for the 20 shopping centers shown in Fig. 2 according to the following steps:

1. Based on the data of questionnaire given in the Appendix find features of the spectators in tour, meals and purchase etc.
2. Suppose each spectator takes collected of twice tour at one day During the Olympic Games, one for get in and out the stadium and another one for meal, and they always adopt the shortest route. Based on the result in 1 please calculate the distribution of consumer flux (in percent) in the 20 shopping centers in Fig. 2.
3. Suppose two different sizes of MS, large and small, can be chosen. Please plan the MS for the 20 shopping centers , i.e. the numbers of different MS in each center such that three requirements are satisfied.
4. Explain that your method is reasonable and the result is practicable.

Remarks :

1. In commerce the ”shopping loop” may be used to describe the covering area of shops. The main factor determining the choice of shop location is the buyer flux with their purchase demand in a shopping loop.

2. For simplicity assume that the National Stadium can admit about 100,000 (spectators), the National Gymnasium about 60,000 and the National Swimming Center about 40,000, where each stand of the three buildings admits about 10,000. Assume also that each exit gate faces just one shopping center, all the shopping center have the same area.

Appendix

Send out questionnaire forms to the spectators three times with 33% reply, total about 10,000 replies. Detail data can be found in the attached access database, where

the ages divided into four levers: 1) Less than 20, 2) 20-30, 3) 30-50 and 4) more than 50. We may design four kinds of tour ways: by taxi, bus, subway and drive car; three kinds of repasts provided: Chinese meal, Western-style food and in marketplace (fast food); and six kinds of expenditure (except for repast): 1) 0-100, 2) 100-200, 3) 200-300, 4) 300-400, 5) 400-500 and 6) more than 500 (RMB ).

Fig.1. The National Stadium
Fig. 2. The National Gymnasium
Fig. 3. The National Swimming Center


Fig. 1

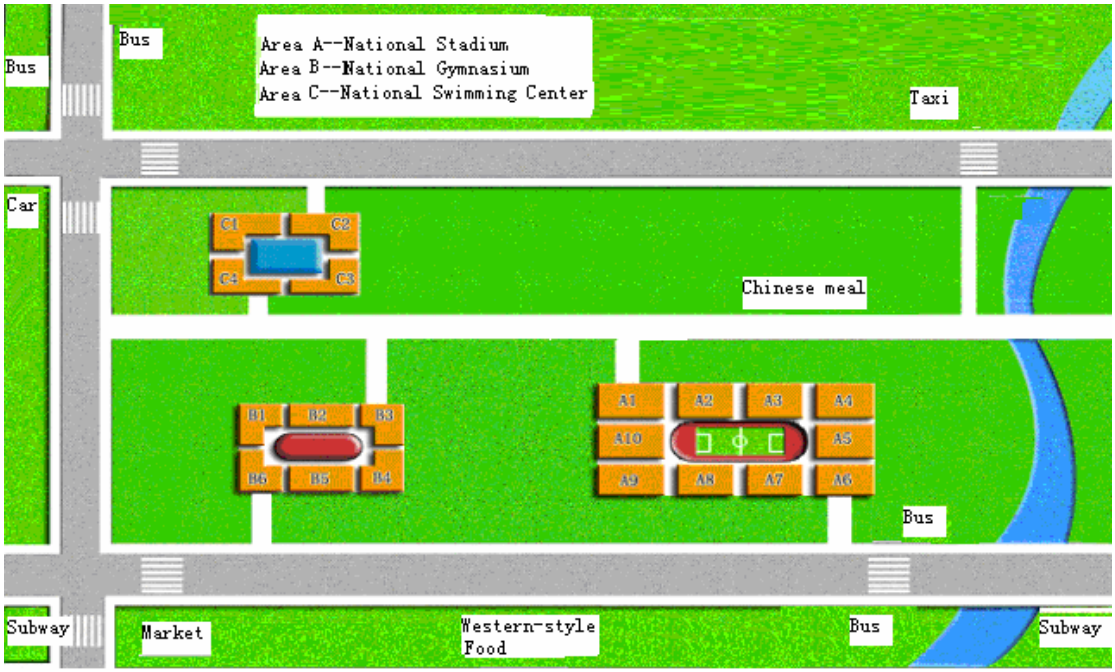


Fig. 2

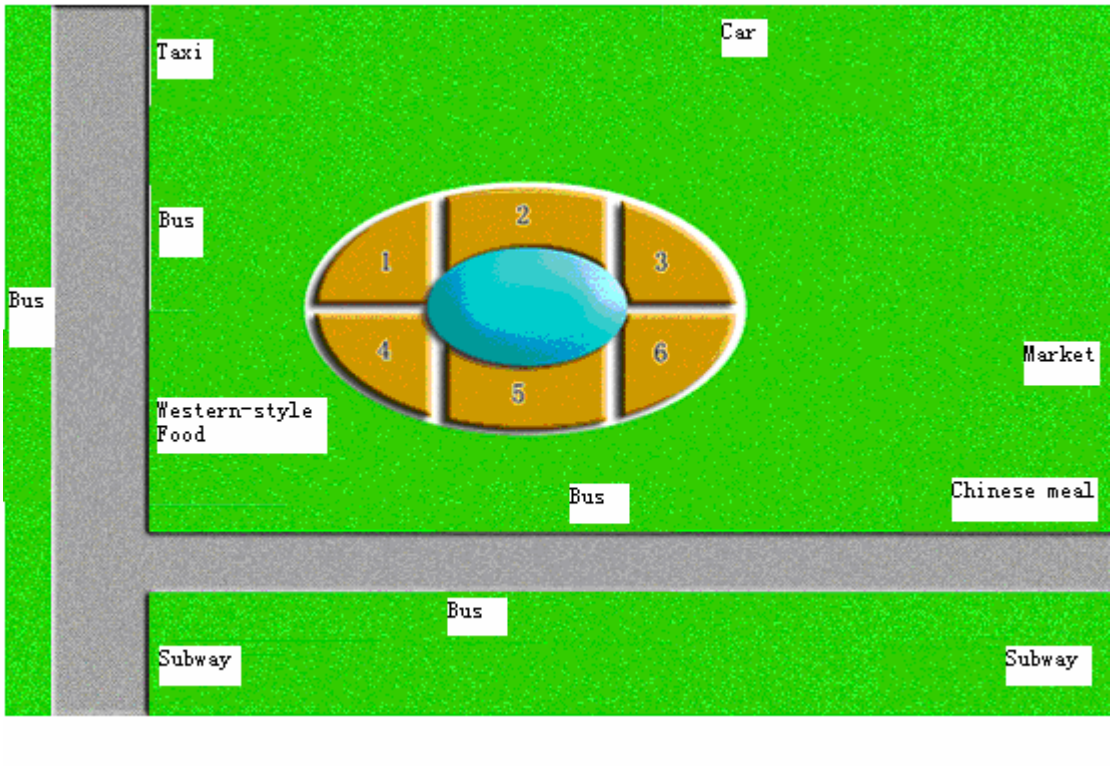


Fig. 3

*(Problem A is proposed by Prof. Meng-Da-zhi from Beijing University of Technology)*

# Problem B: Transmission Congestion Management of Electricity Market

The reform of taking market operations into national electric power systems is moving forward in a fine and steady way. China Electricity Regulatory Commission, which was founded in March, 2003, issued the schedules of establishing the Northeast China region electricity market and operation tests in East China region electricity market in June, 2004, which symbolizes the beginning of the essential stage of the electricity market reform. We can expect that, as the scarcity of electric power is alleviated, the development of the electricity market will enter a new round, which will bring the related industries and research institutions both opportunities and challenges.

From producer to user, electric power runs through four sequential stages -- generation, transmission, distribution, and consumption, all instantly. The initial stage of electricity market in China opens only on the generation side and functions in the market structure model that centralizes the operations of power dispatching and trading into the hand of the market operator—the ISO (Independent System Operator). In the organization of trade, dispatch and distribution, the ISO must follow the 'security first' principle. Meanwhile, it needs to make a trade regulation in the electricity market, and schedule the generation to minimize its cost in buying the electricity. Considering the load forecast and the trade regulation, the ISO makes the schedule of unit outputs (generation), ensuring the system security of the grid. In implementing the schedule, the ISO needs to track the changing load of the system, and make real-time adjustment of the generation of the AGC (Automatic Generation Control, a kind of ancillary services in electric power system) units to balance the change of the load.

Assume that the grid contains several generation units and major transmission lines. The active power flow (power and direction of transmission) of each line is decided by the structure of the grid and the outputs of each unit. The absolute value of the active power flow of each line has its limit set for security, with a relative tolerance (the upper limit of the percentage the absolute value of the flow is allowed to surpass the security limit). If the calculation of the optimal power flow shows surpass of the absolute value of the active power flow over the security limit in any line, it is called transmission congestion. What we need to do is to make a schedule of outputs in both security and economic concern when transmission congestion occurs.

- The trade regulation in electricity market:

1. Every 15 minutes makes a trade period. Each unit submits bids to the ISO for the next period before the end of the last period. The feasible capacity of a unit is divided into at most 10 sectors, the spans of which are called sector capacities, and each sector has its price that is called sector price. Sector price is monotone non-decreasing in terms of the index of sector. Generally, the bid for the capacity under the minimum load of the unit is negative because the loss caused by closing down is even higher.

2. On the basis of the load forecast for the next period, the bids, the current outputs, the ramp rates (the changing rates of the output), the ISO chooses sectors or a certain proportion of a sector of each unit from the sectors of the lowest price to the ones of higher prices (see the annotation below) till the forecast load is met. The chosen sectors and proportion of sector of each unit form the pre-schedule (the initial version of the schedule). The price of the last chosen sector (the highest sector price) is called the market-clearing price (MCP) at which all the energy is bought.

Annotation:

(a) The reference time of periodical load forecasting and scheduling is the end of the period.
(b) The current outputs are the expected outputs at the end of the current period in the schedules.
(c) Assume that the increasing and decreasing rates of output of the same unit have the same value that is called the ramp rate of this unit. The ramping constraints may demand that we choose only part capacities of some sectors (not the entire sector capacities).
(d) In order to meet the forecast load, we may choose only part of a unit's corresponding sector as the market-clearing price.

Operations ISO needs to complete in the current period are as follows:

1. Monitor the implementation of the schedule of dispatch, conduct the AGC ancillary service, and take the AGC into account to decide the current outputs of each unit.
2. Make the load forecast for the next period.
3. Make the pre-schedule of the next period under the trade regulations of the electricity market.
4. Calculate the active power flow of each major line under the pre-schedule, and find out whether there are transmission congestions. If not, accept the pre-schedule; else, operate congestion management under the principles as follows:

● The principles of transmission congestion management:

(1) Adjust the preferred schedules to remove the transmission congestion.
(2) If (1) is not available, the security tolerance of the line is to be employed in order to avoid curtailing loads in the users' side (peremptory act to reduce the electricity demand). Meanwhile, ensure that the excessive percentage over the security limit in each line is as low as possible.
(3) If even (2) is not available, the load curtailing has to be done.
(4) Minimize the congestion cost. When the pre-schedule is modified, some previously chosen generation capacities (Included capacities) are to be out of production, while some un-chosen capacities (Excluded capacities) are to be in production at the market-clearing price which is lower than the price corresponding to the sector. In this case, the economic interests of the sellers and that of the grid are in contradiction. The grid should pay the sellers certain economic compensation for their losses caused by transmission congestion that is called congestion cost. The grid should combine the security of the system and the lowest congestion cost when scheduling.

Your work is as follows:

(1) Assume that the grid contains 8 generation units and 6 major lines. In Table 1 and Table 2, Scheme 0 shows the current outputs of each unit and the corresponding active power flows in each line; Scheme 1~32 show situations which vary from Scheme 0. Try to form each line's approximate expression of the active power flow in terms of the outputs of all units.
(2) Conceive a clear and fair calculation rule of congestion cost. Besides the trade regulation of electricity market, you should pay attention that the included capacities put out of production and the excluded capacities put into production whose corresponding prices are higher than the market-clearing price should be fairly dealt with when the transmission congestion occurs.
(3) Assume that the system loads forecast of next period is 982.4MW. Table 3 and Table 4 show all the sector capacities and the corresponding sector prices of each unit; Table 5 shows the ramp rate of each unit. Try to form a pre-schedule for the next trade period under the trade regulations of the electricity market.

(4) Table 6 shows the power flow limits of all lines. Find out whether there will be transmission congestions under the pre-schedule. If there is, adjust the pre-schedule for both security and economic principles, and calculate the congestion cost corresponding to the modified schedule.
(5) Assume that the system loads forecast of next period is 1052.8MW, repeat procedure 3 and procedure 4.

Table 1 Schedules of outputs (Unit: MW)

| Scheme\Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 0 | 120 | 73 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 1 | 133.02 | 73 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 2 | 129.63 | 73 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 3 | 158.77 | 73 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 4 | 145.32 | 73 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 5 | 120 | 78.596 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 6 | 120 | 75.45 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 7 | 120 | 90.487 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 8 | 120 | 83.848 | 180 | 80 | 125 | 125 | 81.1 | 90 |
| 9 | 120 | 73 | 231.39 | 80 | 125 | 125 | 81.1 | 90 |
| 10 | 120 | 73 | 198.48 | 80 | 125 | 125 | 81.1 | 90 |
| 11 | 120 | 73 | 212.64 | 80 | 125 | 125 | 81.1 | 90 |
| 12 | 120 | 73 | 190.55 | 80 | 125 | 125 | 81.1 | 90 |
| 13 | 120 | 73 | 180 | 75.857 | 125 | 125 | 81.1 | 90 |
| 14 | 120 | 73 | 180 | 65.958 | 125 | 125 | 81.1 | 90 |
| 15 | 120 | 73 | 180 | 87.258 | 125 | 125 | 81.1 | 90 |
| 16 | 120 | 73 | 180 | 97.824 | 125 | 125 | 81.1 | 90 |
| 17 | 120 | 73 | 180 | 80 | 150.71 | 125 | 81.1 | 90 |
| 18 | 120 | 73 | 180 | 80 | 141.58 | 125 | 81.1 | 90 |
| 19 | 120 | 73 | 180 | 80 | 132.37 | 125 | 81.1 | 90 |
| 20 | 120 | 73 | 180 | 80 | 156.93 | 125 | 81.1 | 90 |
| 21 | 120 | 73 | 180 | 80 | 125 | 138.88 | 81.1 | 90 |
| 22 | 120 | 73 | 180 | 80 | 125 | 131.21 | 81.1 | 90 |
| 23 | 120 | 73 | 180 | 80 | 125 | 141.71 | 81.1 | 90 |
| 24 | 120 | 73 | 180 | 80 | 125 | 149.29 | 81.1 | 90 |
| 25 | 120 | 73 | 180 | 80 | 125 | 125 | 60.582 | 90 |
| 26 | 120 | 73 | 180 | 80 | 125 | 125 | 70.962 | 90 |
| 27 | 120 | 73 | 180 | 80 | 125 | 125 | 64.854 | 90 |
| 28 | 120 | 73 | 180 | 80 | 125 | 125 | 75.529 | 90 |
| 29 | 120 | 73 | 180 | 80 | 125 | 125 | 81.1 | 104.84 |
| 30 | 120 | 73 | 180 | 80 | 125 | 125 | 81.1 | 111.22 |
| 31 | 120 | 73 | 180 | 80 | 125 | 125 | 81.1 | 98.092 |
| 32 | 120 | 73 | 180 | 80 | 125 | 125 | 81.1 | 120.44 |

Table 2 Power flow in each line (Unit MW)

| Scheme\Line | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 0 | 164.78 | 140.87 | -144.25 | 119.09 | 135.44 | 157.69 |
| 1 | 165.81 | 140.13 | -145.14 | 118.63 | 135.37 | 160.76 |
| 2 | 165.51 | 140.25 | -144.92 | 118.7 | 135.33 | 159.98 |
| 3 | 167.93 | 138.71 | -146.91 | 117.72 | 135.41 | 166.81 |
| 4 | 166.79 | 139.45 | -145.92 | 118.13 | 135.41 | 163.64 |
| 5 | 164.94 | 141.5 | -143.84 | 118.43 | 136.72 | 157.22 |
| 6 | 164.8 | 141.13 | -144.07 | 118.82 | 136.02 | 157.5 |
| 7 | 165.59 | 143.03 | -143.16 | 117.24 | 139.66 | 156.59 |
| 8 | 165.21 | 142.28 | -143.49 | 117.96 | 137.98 | 156.96 |
| 9 | 167.43 | 140.82 | -152.26 | 129.58 | 132.04 | 153.6 |
| 10 | 165.71 | 140.82 | -147.08 | 122.85 | 134.21 | 156.23 |
| 11 | 166.45 | 140.82 | -149.33 | 125.75 | 133.28 | 155.09 |
| 12 | 165.23 | 140.85 | -145.82 | 121.16 | 134.75 | 156.77 |
| 13 | 164.23 | 140.73 | -144.18 | 119.12 | 135.57 | 157.2 |
| 14 | 163.04 | 140.34 | -144.03 | 119.31 | 135.97 | 156.31 |
| 15 | 165.54 | 141.1 | -144.32 | 118.84 | 135.06 | 158.26 |
| 16 | 166.88 | 141.4 | -144.34 | 118.67 | 134.67 | 159.28 |
| 17 | 164.07 | 143.03 | -140.97 | 118.75 | 133.75 | 158.83 |
| 18 | 164.27 | 142.29 | -142.15 | 118.85 | 134.27 | 158.37 |
| 19 | 164.57 | 141.44 | -143.3 | 119 | 134.88 | 158.01 |
| 20 | 163.89 | 143.61 | -140.25 | 118.64 | 133.28 | 159.12 |
| 21 | 166.35 | 139.29 | -144.2 | 119.1 | 136.33 | 157.59 |
| 22 | 165.54 | 140.14 | -144.19 | 119.09 | 135.81 | 157.67 |
| 23 | 166.75 | 138.95 | -144.17 | 119.15 | 136.55 | 157.59 |
| 24 | 167.69 | 138.07 | -144.14 | 119.19 | 137.11 | 157.65 |
| 25 | 162.21 | 141.21 | -144.13 | 116.03 | 135.5 | 154.26 |
| 26 | 163.54 | 141 | -144.16 | 117.56 | 135.44 | 155.93 |
| 27 | 162.7 | 141.14 | -144.21 | 116.74 | 135.4 | 154.88 |
| 28 | 164.06 | 140.94 | -144.18 | 118.24 | 135.4 | 156.68 |
| 29 | 164.66 | 142.27 | -147.2 | 120.21 | 135.28 | 157.65 |
| 30 | 164.7 | 142.94 | -148.45 | 120.68 | 135.16 | 157.63 |
| 31 | 164.67 | 141.56 | -145.88 | 119.68 | 135.29 | 157.61 |
| 32 | 164.69 | 143.84 | -150.34 | 121.34 | 135.12 | 157.64 |

Table 3 Sector capacities of each unit (Unit: MW)

| Unit\Sector | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 70 | 0 | 50 | 0 | 0 | 30 | 0 | 0 | 0 | 40 |
| 2 | 30 | 0 | 20 | 8 | 15 | 6 | 2 | 0 | 0 | 8 |
| 3 | 110 | 0 | 40 | 0 | 30 | 0 | 20 | 40 | 0 | 40 |
| 4 | 55 | 5 | 10 | 10 | 10 | 10 | 15 | 0 | 0 | 1 |
| 5 | 75 | 5 | 15 | 0 | 15 | 15 | 0 | 10 | 10 | 10 |
| 6 | 95 | 0 | 10 | 20 | 0 | 15 | 10 | 20 | 0 | 10 |
| 7 | 50 | 15 | 5 | 15 | 10 | 10 | 5 | 10 | 3 | 2 |
| 8 | 70 | 0 | 20 | 0 | 20 | 0 | 20 | 10 | 15 | 5 |

Table 4 Sector prices of each unit (Unit: yuan/MWh)

| Unit\Sector | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -505 | 0 | 124 | 168 | 210 | 252 | 312 | 330 | 363 | 489 |
| 2 | -560 | 0 | 182 | 203 | 245 | 300 | 320 | 360 | 410 | 495 |
| 3 | -610 | 0 | 152 | 189 | 233 | 258 | 308 | 356 | 415 | 500 |
| 4 | -500 | 150 | 170 | 200 | 255 | 302 | 325 | 380 | 435 | 800 |
| 5 | -590 | 0 | 116 | 146 | 188 | 215 | 250 | 310 | 396 | 510 |
| 6 | -607 | 0 | 159 | 173 | 205 | 252 | 305 | 380 | 405 | 520 |
| 7 | -500 | 120 | 180 | 251 | 260 | 306 | 315 | 335 | 348 | 548 |
| 8 | -800 | 153 | 183 | 233 | 253 | 283 | 303 | 318 | 400 | 800 |

Table 5 Ramp rate of each unit (Unit: MW/minute)

| Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Rate | 2.2 | 1 | 3.2 | 1.3 | 1.8 | 2 | 1.4 | 1.8 |

Table 6 Power flow limit and relative security tolerance of each line (Unit: MW)

| Line | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Limit | 165 | 150 | 160 | 155 | 132 | 162 |
| Relative Tolerance | 13% | 18% | 9% | 11% | 15% | 14% |

*(Problem B is proposed by Prof. Liu Kang-sheng from Zhejiang University, China)*

# Problem C: Drinking and Driving

Newspapers alleged that fatalities in traffic crashes throughout the country in 2003 reached 104, 372, out of which a significant percentage was caused by alcohol-related driving.

In view of the serious situation of transportation safety, GAQSIQ (General Administration of Quality Supervision , Inspection and Quarantine of the People's Republic of China), on May 31 of 2004, has issued an updated national standard《threshold of alcohol content and inspection in both blood and breath out for vehicle drivers 》. The new standard stipulates that it is classified as drinking drive for a vehicle driver if his or her blood alcohol concentration is greater than or equal to 20mg/100ml, meanwhile, less than 80 mg/100ml ( previous standard is less than 100 mg/100ml); it is classified as drunk drive if the alcohol concentration of the blood is greater than or equal to 80mg/100ml (previous standard is greater than or equal to 100 mg/100ml).

Mr. Lee drank a bottle of beer at noon, then at 6 pm he happened to be inspected and met the driving standard , he drank again a bottle of beer at supper before 7 pm, for sure he stayed up until 2 am in the next early morning and then drove home, unfortunately, facing inspection once more and was classified as drinking drive. It makes him upset and puzzled: why the two results of inspection are so different after drinking the same amount of beer?

Please consult the data given below (or colleting data by yourself), construct a mathematical model for alcohol concentration of the blood after drinking and discuss the following questions:

1. Explain the situation encountered by Mr. Lee;
2. During how long time after drinking 3 bottles of beer or 250 grams of low-degree spirits driving would violate the new standard, please answer the question under the following conditions:
   1) Drinking in a very short time period;
   2) Drinking in a relatively long time period (e.g. in 2 hours).
3. Estimate when the alcohol concentration of the blood will reach its maximum.
4. Based on your model, put forward an argument: if a driver drinks every day, the driver can still drive legally?
5. Combining the new national standard and your model, write an essay to give an advice for those drivers who is willing to have beverage with alcohol.

# Reference data

1. In general, body fluid amount to 65% to 70% of the body weight, in which blood only amount to about 7%; and drug (including alcohol) concentration in both blood and body fluid are nearly the same.
2. Someone whose body weight is approximately 70kg drank 2 bottles of beer in a short time period, his alcohol concentration of the blood is measured (mg/100ml) as time elapsed, the resulting data are as follows:

| Time (hour) | 0.25 | 0.5 | 0.75 | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alcohol concentration | 30 | 68 | 75 | 82 | 82 | 77 | 68 | 68 | 58 | 51 | 50 | 41 |
| Time (hour) | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | |
| Alcohol concentration | 38 | 35 | 28 | 25 | 18 | 15 | 12 | 10 | 7 | 7 | 4 | |

*(Problem C is proposed by Prof. Jiang Qi-yuan from Tsinghua University, et al.)*

# Problem D: Recruiting Government Officers

In China, the government officer system has been implemented for many years. In *Interim Regulations of Government Officer* published on 1 October , 1993. It definitely says that non-leading position government officers below section chiefs should be recruited by open and strict examinations. At present, the procedure of recruiting government officers includes the following three stages: open examination (written examination), interview, and recruiting right persons

A government division of a city is planning to recruit eight officers for its 7 departments. The specific recruiting procedure is as follows:

1. Open examination: Any person who satisfies the conditions: age under 30, graduated from two-year colleges or universities, and healthy is legally for applying for the open examination. The examination subjects include “basic knowledge”, “professional courses”, and "executive ability test”. The full mark of each subject is 100. After written examinations, the first 16 applicants will enter into the second round––interview.
2. Interview: In this stage, a committee of consisting of 8 experts will interview the 16applicants. They mainly examine applicants’ integrated qualities such as width of knowledge, faculty of knowing and comprehending, flexibility, faculty of both oral and written communication and so on. According to given criteria , the experts have to give every applicant one grade from A, B, C, D to each examination subject. The committee gives the final grade for applicant. Detail results are showed in table 1.
3. Combining the opinions of the expert committee, scores of written examination and requirements of each department, the recruiting committee of the division will determine the employee list and assign them to the departments.

Suppose the division plans to employ 8 government officers and assign them to 7 different departments. Furthermore, each has to hire at least one government officer. The work of those 7 departments can be classified into four categories: (1) administrative management, (2) technical management, (3) executive and law department, (4) public affairs.

During the recruiting process the principles of fairness, publicity and take rationality of the assignment and well exerting one’s talent into consideration should be emphasized. Fundamental status (including welfare, working condition, labor intensity, opportunity of promotion, opportunity of further education and so on) of the 7 departments and also the different expectations of the four types of work are opened to applicants (details are showed in tables 2A and 2B). Every interviewer can apply for two types of his/her favorite work (showed in table 1). Now, the problems are:

(1) If ignoring applicants’ own will, according to their ability and departments’ need, please help the recruiting committee design an employing scheme.
(2) Taking the applicants’ will and expectations of the departments into

consideration, please help the recruiting committee design an employing scheme.

(3) Is your scheme feasible to the general case of $N$ applicants and $M$ departments?

(4) In your opinion, where are still deserved modifications, in the whole process of recruitment? Please give your suggestions.

Table 1: scores of written examination and interview grades of expert committee

| Number of applicants | Total score of the written examination | Applicant's will | | Grades of applicants' specific ability given by the expert committee | | | |
|---|---|---|---|---|---|---|---|
| | | | | Width of professio-nal knowledge | Faculty of knowing and comprehending | Flexibility | Expressive ability |
| 1 | 290 | （2） | （3） | A | A | B | B |
| 2 | 288 | （3） | （1） | A | B | A | C |
| 3 | 288 | （1） | （2） | B | A | D | C |
| 4 | 285 | （4） | （3） | A | B | B | B |
| 5 | 283 | （3） | （2） | B | A | B | C |
| 6 | 283 | （3） | （4） | B | D | A | B |
| 7 | 280 | （4） | （1） | A | B | C | B |
| 8 | 280 | （2） | （4） | B | A | A | C |
| 9 | 280 | （1） | （3） | B | B | A | B |
| 10 | 280 | （3） | （1） | D | B | A | C |
| 11 | 278 | （4） | （1） | D | C | B | A |
| 12 | 277 | （3） | （4） | A | B | C | A |
| 13 | 275 | （2） | （1） | B | C | D | A |
| 14 | 275 | （1） | （3） | D | B | A | B |
| 15 | 274 | （1） | （4） | A | B | C | B |
| 16 | 273 | （4） | （1） | B | A | B | C |

Table 2A: fundamental status of the departments

| Number of departments | Type of work | Fundamental status of the departments | | | | |
|---|---|---|---|---|---|---|
| | | Welfare | Working condition | Labor intensity | Promotion opportunity | Opportunity of further education |
| 1 | （1） | Good | Good | Average | Much | Little |
| 2 | （2） | Average | Good | Great | Much | Little |
| 3 | （2） | Average | Good | Average | Little | Much |
| 4 | （3） | Good | Bad | Great | Little | Much |
| 5 | （3） | Good | Average | Average | Average | Average |
| 6 | （4） | Average | Average | Average | Average | Much |
| 7 | （4） | Good | Average | Great | Little | Much |

Table 2B: expectations of the departments

| Number of departments | Type of work | Expectations of the departments | | | |
|---|---|---|---|---|---|
| | | Width of professional knowledge | Faculty of knowing and comprehending | Flexibility | Expressive ability |
| 1 | （1） | B | A | C | A |
| 2 | （2） | A | B | B | C |
| 3 | （2） | | | | |
| 4 | （3） | C | C | A | A |
| 5 | （3） | | | | |
| 6 | （4） | C | B | B | A |
| 7 | （4） | | | | |

*(Problem D is proposed by Prof. Han Zhong-geng from PLA University of Information Engineering)*