**2021 May Day MCM**

Problem B. Fire Rescue Problem

With the rapid development of China's economy, the complexity of the urban space environment has risen sharply, various accidents and disasters have occurred frequently, and safety risks have continued to increase. The tasks of fire rescue teams have also shown a trend of diversification and complexity. For every police incident, the fire rescue team will make a detailed record。

There are 15 areas in a region, denoted by A, B, C... respectively. The positional relationship and distance of each area are shown in Figure 1. The population and acreage of each area are shown in Appendix 1, and the fire alarm data of the fire rescue team is shown in Appendix 2.

Please use the fire alarm data of the above area and reply the following questions:

**Question 1**: Divide every day into three time periods (0:00-8:00 is time period I, 8:00-16:00 is time period II, and 16:00-24:00 is time period III), no less than 5 people on duty in each time period. Assuming that the fire brigade have 30 people that can be arranged on duty every day, based on the attached data，please establish a mathematical model to determine how many people should be on duty in each time periods (0:00-8:00 is time period I, 8:00-16:00 is time period II, and 16:00-24:00 is time period III) of the first day of February, May, August, and November.

**Question 2**: Based on the data of Appendix 1 and set a month as a unit，to establish a predictive model for the number of alarms of fire rescue. Use the data from January 1, 2020 to December 31, 2020 as the validation data set for the model to evaluate the accuracy and stability of the predictive model. Then, predict the number of fire rescue alarms in each month of 2021, and fill in Table 1.

**Question 3**: Based on the occurrence time of 7 types of fire rescue events and set a month as a unit，to establish mathematical models of the number of occurrences of each event. Determine the optimal model for the number of occurrences of each event with the best fit as the evaluation criterion.

**Question 4**: According to Figure 1, to establish a suitable model to analyze the correlation in space of the event density of each category in the region from 2016 to 2020, and give the most relevant event categories in different regions (Event density is the number of events that occur per week per square kilometer).

**Question 5**: According to Appendix 2, establish related mathematical model to analyze the relationship between the density of various types of events and the population density (population density refers to the number of people per square kilometer).

**Question 6**: There are two fire stations in the region, located in area J and area N. If one new fire station is built, please use the data in Appendix 1 and Appendix 2, comprehensively consider various factors and establish a mathematical model to determine the area where the new fire station should be built? If one new fire station is built every 3 year from 2021 to 2029, which areas should the three new fire stations be built in order.



Figure1 The positional relationship and distance of each area（The unit of distance in the figure is km）

Table1 The result of question 2

|  |  |
| --- | --- |
| Month | Forecast value (times) |
| January 2021 |  |
| February 2021 |  |
| March 2021 |  |
| April 2021 |  |
| May 2021 |  |
| June 2021 |  |
| July 2021 |  |
| August 2021 |  |
| September 2021 |  |
| October 2021 |  |
| November 2021 |  |
| December 2021 |  |