|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | For office use only | | | T1 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | T2 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | T3 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | T4 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | |  | | --- | | Team Control Number  **00000** | |  | | Problem Chosen  **A** | | |  |  | | --- | --- | | For office use only | | | F1 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | F2 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | F3 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | F4 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | |

**2018 Mathematical Contest in Modeling (MCM) Summary Sheet**

**Title**（此处应写论文标题）

**Summary**

美赛论文的摘要的英文一般用Summary，摘要最好在本页完成。

**标题**为16号Times New Roman字体加粗并居中

**摘要**为14号Times New Roman字体加粗并居中

**关键词**为12号Times New Roman字体加粗并居左

**行间距一般为1倍行距，为控制在一页可适当调整。**

首页不需要页眉和页码。

“00000”修改为自己的控制编号（Team Control Number），“A”改为自己的选题题号（A/B/C/D/E/F）

**Key words:** 三到五个关键词

注：红色字为解释说明部分，使用时应全部删除或换成黑色字。

**Contents**

[I. Introduction 4](#_Toc471658476)

[1.1 Background 4](#_Toc471658477)

[1.2 Our works 4](#_Toc471658478)

[II. The Description of the Problem 5](#_Toc471658479)

[2.1 Problem statement 5](#_Toc471658480)

[2.2 Analysis of Specific Issues 5](#_Toc471658481)

[2.2.1 Analysis of Problem 1 5](#_Toc471658482)

[2.2.2 Analysis of Problem 2 5](#_Toc471658483)

[2.2.3 Analysis of Problem 3 5](#_Toc471658484)

[2.2.4 Analysis of Problem 4 6](#_Toc471658485)

[III. Basic assumption 6](#_Toc471658486)

[IV. Glossary & Symbols 6](#_Toc471658487)

[4.1 Glossary 6](#_Toc471658488)

[4.2 Symbols 7](#_Toc471658489)

[V. Models 7](#_Toc471658490)

[5.1 Analysis and Solving of Question One 7](#_Toc471658491)

[5.1.1 Model Preparation 7](#_Toc471658492)

[5.1.2 Model Establishment 8](#_Toc471658493)

[5.1.3 Model solving 8](#_Toc471658494)

[5.1.4 Analysis of the Result 9](#_Toc471658495)

[5.2 Analysis and Solving of Question Two 9](#_Toc471658496)

[5.2.1 Model Preparation 9](#_Toc471658497)

[5.2.2 Model Establishment 10](#_Toc471658498)

[5.2.3 Model solving 10](#_Toc471658499)

[5.2.4 Analysis of the Result 11](#_Toc471658500)

[5.3 Analysis and Solving of Question Three 11](#_Toc471658501)

[5.3.1 Model Preparation 11](#_Toc471658502)

[5.3.2 Model Establishment 12](#_Toc471658503)

[5.3.3 Model solving 13](#_Toc471658504)

[5.3.4 Analysis of the Result 13](#_Toc471658505)

[5.4 Analysis and Solving of Question Four 13](#_Toc471658506)

[5.4.1 Model Preparation 13](#_Toc471658507)

[5.4.2 Model Establishment 14](#_Toc471658508)

[5.4.3 Model soving 15](#_Toc471658509)

[5.4.4 Analysis of the Result 15](#_Toc471658510)

[VI. Error Analysis and Sensitivity Analysis 15](#_Toc471658511)

[6.1 Error Analysis 15](#_Toc471658512)

[6.1.1 Error Analysis of Model One 15](#_Toc471658513)

[6.1.2 Error Analysis of Model Two 15](#_Toc471658514)

[6.1.3 Error Analysis of Model Three 16](#_Toc471658515)

[6.2 Sensitivity Analysis 16](#_Toc471658516)

[6.2.1 Sensitivity Analysis of Model One 16](#_Toc471658517)

[6.2.2 Sensitivity Analysis of Model Two 16](#_Toc471658518)

[6.2.2 Sensitivity Analysis of Model Three 16](#_Toc471658519)

[VII. Evaluation and Promotion of Model 16](#_Toc471658520)

[7.1 Strength and Weakness 16](#_Toc471658521)

[7.1.1 Strength 16](#_Toc471658522)

[7.1.2 Weakness: 17](#_Toc471658523)

[7.2 Promotion 17](#_Toc471658524)

[Ⅷ. Conclusions 17](#_Toc471658525)

[8.1 Conclusions of the problem 17](#_Toc471658526)

[8.2 Methods used in our models 17](#_Toc471658527)

[I X. References 18](#_Toc471658528)

[X. Appendix 18](#_Toc471658529)

[10.1 Appendix One 18](#_Toc471658530)

[10.2 Appendix Two 18](#_Toc471658531)

从目录开始有页眉和页码，把“00000”改为自己的控制编号，页码会自动调整可以不用编辑。

# I. Introduction

## 1.1 Background

在此开始正文，

正文的一级标题为16号Times New Roman字体加粗并居中

正文的二级标题为14号Times New Roman字体加粗并居左

正文的三级标题为12号Times New Roman字体加粗并居左

一般不设四级标题，若有的话请用（1）或1）或①等代替为11号Times New Roman字体加粗并居左

正文部分为11号Times New Roman字体不加粗

英文文章的段落开头一般是居左并无缩进的，即段首顶格书写。

从目录开始有页眉和页码，把“00000”改为自己的控制编号，页码会自动调整可以不用编辑。

## 1.2 Our works

* Task 1
* Task 2
* Task 3
* Task 4

# II. The Description of the Problem

## 2.1 Problem statement

Fig1. thinking research paper figure

## 2.2 Analysis of Specific Issues

2.2.1 Analysis of Problem 1

2.2.2 Analysis of Problem 2

2.2.3 Analysis of Problem 3

2.2.4 Analysis of Problem 4

# III. Basic assumption

* The convection of water inside the bath tub does not affect the current water temperature. The reason is that heat exchange caused by convective occurs only between the parts of the water in the bathtub, this process does not get heat exchange from the outside of the system, in other words, only water temperature distribution changed.

# IV. Glossary & Symbols

## 4.1 Glossary

* Load degree: V / C is maximum traffic service divided by basic capacity under ideal conditions,. The basic capacity is the maximum amount of traffic on the four-hour service level half.

## 4.2 Symbols

|  |  |  |
| --- | --- | --- |
| **Symbols** | **Definition** | **Units** |
| **Z** | The index of development | J |
| **CI** | Coordinated index of development | J |
| **DI** | Sustainability index of development | J |
| **A** | Economic index of development | J |
| **B** | Social index of development | K |
| **C** | Environment index of development | K |
| **F** | Impact index value | km3 |
| **S** | Reality index value | m |
|  | Influence coefficient | m2 |

# V. Models

## 5.1 Analysis and Solving of Question One

5.1.1 Model Preparation

Assume that the total number of people in the area examined during the period of Aka drug transmission remains unchanged, regardless of birth rate and mortality, or population migration. The population is divided into two categories: no taking Aka and taking Aka. , hereinafter referred to as healthy people and patients. And at the time t, the proportion of these two groups of people in the total number N is s(t) and i(t). The average number of people who can effectively contact each patient every day and make healthy people take Aka drugs is constant λ. λ is called the daily contact infection rate, which means that when the patient is in effective contact with the healthy person, the healthy person is infected and becomes a patient. The proportion of patients who are cured every day is a constant μ, called the daily cure rate, which can be expressed as the proportion of successful people who are detoxified every day. In particular, patients can still take Aka drugs repeatedly after the patient is cured. It is obvious that 1/μ is the average infection period during the drug's transmission period. In this way, we can establish a differential equation model for the spread of Aka drugs similar to the model of infectious disease transmission.

5.1.2 Model Establishment

**Step1:** Establish differential equations based on the characteristics of Aka drugs

（1）

**Step2:** Further simplification

（2）

}

**Step3:** Know the results

= （3）

**Step4:** Defining σ=λ / μ, noting the meaning of λ and 1/μ, we can see that σ is the ratio of the daily infection rate to the daily cure rate during the whole propagation period, called the number of contacts. With σ, the model can be rewritten as:

) ] （4）

**Step5:** Separate variables and further simplify

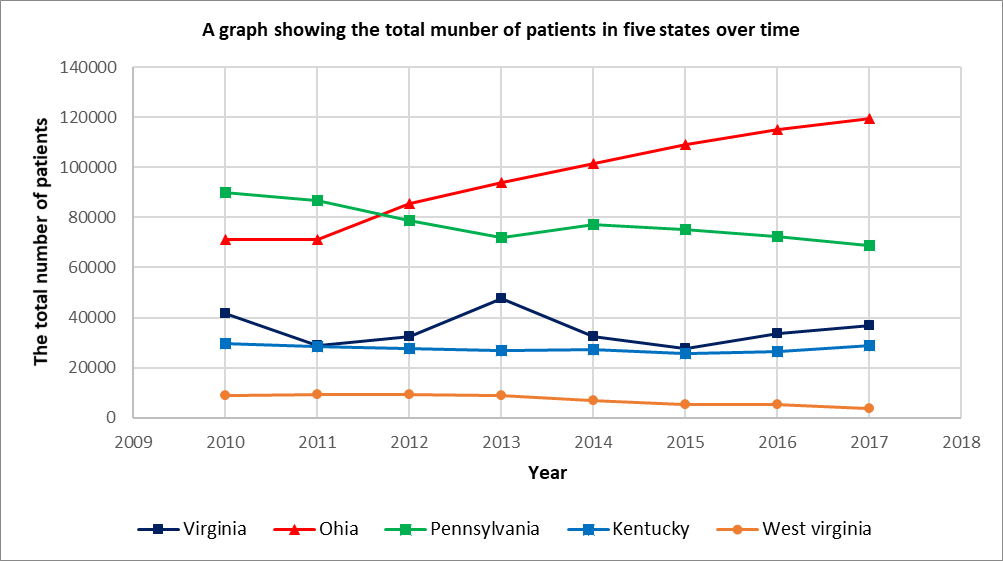
= （5）

**Step6:** Find the points on both sides and solve them.

**（c is the parameter） （6）**

5.1.3 Model soving

Figure 1 shows the relationship between the total number of patients in five continents over time, and Figure 2 shows the geographical relationship between the five continents. It can be seen from the figure that the total number of patients in Ohia has been increasing, and the total number of patients in Pennsylvania is decreasing. The trend of the total number of patients in the other three states over time is not very obvious.

fig1.The total number of patients in five states over time fig.2 The geography of the five continents

The analysis shows that the rule of Aka drug propagation process is the same between different states. In order to make the description law more significant, the formula (6) is solved by using Ohia data as an example, and solved by Matlab software. , so that the sum of squared residuals is the smallest, ie

min {SSE=}.

Obtain：

，SSE=0.000014.

The function of the Aka drug infection rate in Ohia over time is

（7）

5.1.4 Analysis of the Result

（1）From σ=1.259, λ >μ, the daily contact transmission rate of the opioid-like drugs is greater than the daily cure rate, which is consistent with the increasing trend of the opioid drug infection rate in Ohia Prefecture from 2010 to 2017, and the residual square sum SSE=0.000014 is extremely small. , indicating that the model has a good fit.

（2）The analysis shows that the contact number σ=1 is a threshold. When σ>1, the increase and decrease of i(t) depends on the size of i\_0, but its limit value increases with the increase of σ; When σ ≤ 1, the proportion of patients i(t) is getting smaller and smaller, and eventually tends to 0. This is because the number of healthy people who become patients during the transmission period does not exceed the original number of patients.

（3）In this way, the US government needs to pay special attention to the critical value σ. When the number of patients increases with σ>1, the social security situation may be worsened, taking into account the ratio of the number of Aca drugs taken to the total number of Aka drugs. Stable in the short term, and the cure rate, that is, the compulsory detoxification rate, is basically unchanged under certain government policies (such as social security). All of us can estimate the total infection rate λ according to the usage rate of specific Aka drugs. Compared with the cure rate μ, for example, when λ>μ, the number of patients will increase, and the government needs to develop measures such as strengthening social security. Taking Ohia as an example, it can be seen from Table 2 that the number of patients in Heroin accounts for The total number of people is 30.5%, so that the total number of patients and the infection rate can be estimated accurately based on the number of patients in Heroin, and then analyzed with the critical value, so that the problem 1 is well solved.

**Table2.The percentage of all drug sick in 2010 Ohia**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Heroin** |  | **Methadone** | **Morphine** | **…** | **Oxycodone** | **Buprenorphine** |
| **Percentage** | **0.305** |  | **0.0246** | **0.0209** | **…** | **0.122** | **0.377** |

## 5.2 Analysis and Solving of Question Two

5.2.1 Model Preparation

Fig3. thinking research paper figure

5.2.2 Model Establishment

* + **Step1:**
  + **Step2:**
  + **Step3:**

* + **Step4:**
  + **Step5:**
  + **Step6:**
  + **Step7:**
  + **Step8:**
  + **Step9:**

5.2.3 Results

5.2.4 Analysis of the Result

## 5.3 Analysis and Solving of Question Three

5.3.1 Model Preparation

**(1) Data Processing**



**(2) Assumptions**

**(3) The Foundation of Model**

Fig4. thinking research paper figure

5.3.2 Model Establishment

* + **Step1:**
  + **Step2:**
  + **Step3:**

* + **Step4:**
  + **Step5:**
  + **Step6:**
  + **Step7:**
  + **Step8:**
  + **Step9:**

5.3.3 Results

**Table 3 The results of the model parameter value table**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

5.3.4 Analysis of the Result



Fig5. Basketball Coaches

## 5.4 Analysis and Solving of Question Four

5.4.1 Model Preparation

**(1) Data Processing**



**(2) Assumptions**

**(3) The Foundation of Model**

5.4.2 Model Establishment

* + **Step1:**
  + **Step2:**
  + **Step3:**

* + **Step4:**
  + **Step5:**
  + **Step6:**
  + **Step7:**
  + **Step8:**
  + **Step9:**



Fig6. Traffic flow changes with the rate of large truck

5.4.3 Results

**Table 4 The results of the model parameter value table**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

5.4.4 Analysis of the Result

# VI. Error Analysis and Sensitivity Analysis

## 6.1 Error Analysis

6.1.1 Error Analysis of Model One

6.1.2 Error Analysis of Model Two

6.1.3 Error Analysis of Model Three

## 6.2 Sensitivity Analysis

6.2.1 Sensitivity Analysis of Model One

6.2.2 Sensitivity Analysis of Model Two

6.2.2 Sensitivity Analysis of Model Three

# VII. Evaluation and Promotion of Model

## 7.1 Strength and Weakness

7.1.1 Strength

7.1.2 Weakness:

## 7.2 Promotion

# Ⅷ. Conclusions

## 8.1 Conclusions of the problem

## 8.2 Methods used in our models

# I X. References

[1] Xu Lun Hui,Luo Qiang,Fu Hui.Car following safe distance model based on braking process of leading vehicle f [J].Journal of Guangxi Normal University(Natural Science Edition),2010,28(1):1-5.

[2]

[3]

[4]

# X. Appendix

## 10.1 Appendix One

美赛中可以有附录也可以没有附录，即此部分可以省略

## 10.2 Appendix Two