

CHAPTER I

INTRODUCTION

I.1 Research Background

COVID-19 is a disease caused by a new strain of coronavirus that's currently a major threat to populations around the world. Symptoms of the disease may include fever, cough and shortness of breath (WHO, 2020). In more severe cases, infection can cause pneumonia and breathing difficulties, and in the most severe cases, the disease can be fatal. The virus is transmitted through direct contact with respiratory droplets of an infected person.

The first human cases of COVID-19 was reported by officials in Wuhan, China, in December 2019 and is still increasing at the time of writing. By January 31, the global confirmed cases have reached 9,776 with a death toll of 213, and the WHO declared the outbreak as a public health emergency of international concern (WHO, 2020). As of June 29, 2021, total confirmed cases has reached 10,021,401 (WHO, 2020).

As the number of cases continues to increase, it is essential for public health authorities to do containment measures to control the spread of this pandemic. As such, it is necessary to know the trend of the disease. One such way to study the spread of the disease is using a mathematical model. A mathematical model describes a system using mathematical language and tools. Mathematical models are developed to help explain a system, to study the effects of its various components, and to make predictions about their behavior.

One of such model is the Susceptible-Infected-Removed (SIR) model. SIR model is a mathematical model of the spread of an infectious disease that examines how a disease spread into a population. This model, as its name implies, divides the population into three non-intersecting class. As an indi-

vidual that was healthy gets infected with the disease, and then cured from the disease, that individual moves from one class to another (Susceptible when healthy, infected when sick, removed when cured). The change in number of individual of each class follows an exponential trend.

In physics, this exponential trend can similarly be observed in a nuclear decay. Nuclear decay is a process where an unstable nucleus loses energy and undergoes a decay process to become a more stable daughter nucleus [ER85]. A similar scenario with the SIR model mentioned above can be observed in a successive nuclear decay, in which a daughter nucleus that was a result of a decay undergoes another nuclear decay process, creating a second generation daughter nucleus. This is similar to how an individual that is infected with a disease moves through the classes in the SIR model. A healthy individual first become infected with a disease, moving that individual to the infected class. When that individual recovers from the disease, it then again moves class, this time to the removed or recovered class. Of course, since the decay phenomenon is a statistical process, a probability parameter is needed. In nuclear decay, there is λ (or R in some literatures) that represents the decay probability. Meanwhile, in a SIR model, there are two such parameters, the transmission rate (β) and recovery rate (α) of the disease.

In this study, transmission and recovery rate of the disease will be evaluated using the SIR model. More on SIR model will be explained in subchapter II.3. A test case will be done first in order to obtain more basic knowledge about SIR model. The chosen test case is Problem 9.14 from [BC12]. Then, the knowledge obtained will be applied in a real set of COVID-19 data. The data in this case will be Indonesia's data, from the first recorded case in March 2020 to March 2021, spanning exactly 365 days, and the data of two other countries, Germany and Tajikistan, from February 2020 to February 2022. Germany and Tajikistan were both chosen to provide comparison to Indonesia's data, because of the difference in the ways each countries handle the COVID-19 outbreak. The difference in the obtained data and the simulation from the SIR model

is then analyzed qualitatively, to give context to the result. Both SIR model simulation and Indonesia's COVID-19 data will be processed using *Wolfram Mathematica*. More regarding *Mathematica* will be explained in Sub-chapter II.4.

I.2 Problem Statement

Based on the research background, this research is going to focus on **evaluating the transmission rate and recovery rate of COVID-19 in Indonesia, Germany, and Tajikistan..**

I.3 Research Goal

The aim of this research is to evaluate transmission and recovery rate of COVID-19 in Indonesia, Germany, and Tajikistan.

I.4 Problem Limitation

1. Assumptions that SIR model makes applies, which includes:
 1. Population remains constant.
 2. Infected individuals are also infectious.
 3. Recovered individuals have complete immunity to the disease.
2. The data used is the COVID-19 data of Indonesia, Germany, and Tajikistan. The data is obtained from the data released by local authorities.
3. The COVID-19 data used in this research were from March 2020 to September 2021 for Indonesia, and from February 2020 to February 2022 for both Germany and Tajikistan.

I.5 Outcome

Learning about SIR model will give basic understanding regarding the mathematical modeling of a pandemic, and its presumed similarity with Nuclear Decay in physics. The results of this research will be a good starting point to branch out to more complicated mathematical model of a disease.