SEIR Model Analysis for The Spread of Covid-19 Disease Post New Normal Using Euler Method and Matlab-Assisted Heun Method

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Abstract
In early 2020 Corona Virus Disease 2019 (COVID-19) was declared by WHO as a pandemic and the Government of Indonesia based on Presidential Decree Number 11 of 2020 concerning the Determination of Public Health Emergency of Corona Virus Disease 2019 (COVID-19). On this basis, this study aims to find out the solution to the numerical solution of the SEIR epidemic on the rate of Coronavirus Disease (COVID-19) by using the Euler method and the Heun method and to find out the design of a mathematics lesson plan in high school that is in accordance with the concept of the numerical method. In analyzing the spread of the Covid-19 disease after the new normal, a mathematical model of the Covid-19 disease was developed using the SEIR type with the stages of Literature Study, Mathematical Modeling, Model Analysis, Simulation and Drawing conclusions. The target to be achieved in this research is to produce mathematical modeling from the results of the analysis that carried out, reports can be confirmed and report results can be published in international journals. This research will produce TKT types of social humanities and education with the results of the status of R&D results are important and significant for supporting decisions and policies.
Keywords: Model SEIR, EULER, HEUN, MATLAB.
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Introduction

In early 2020, the world was shocked by the outbreak of a new virus, namely a new type of coronavirus (SARS-CoV-2) or the disease is called *Coronavirus Disease (COVID-19).* It is known, that the origin of this virus originated from Wuhan, China which was discovered at the end of December 2019. Until now, it has been confirmed that there are hundreds of countries that have contracted this virus. Corona Virus Disease 2019 (COVID-19) has been declared by WHO as a pandemic and the Government of Indonesia based on Presidential Decree Number 11 of 2020 concerning the Determination of Corona Virus Disease 2019 (COVID-19) Public Health Emergency has declared COVID-19 as a public health emergency that must be carried out countermeasures (KEPPRES, 2020).

Corona virus infection itself symptoms are quite difficult to know at first. This is because not everyone who has been infected will immediately show the early symptoms of the Corona virus itself. To find out, it takes 2 to 14 days for the infected person to release the characteristics of the Corona virus (Syauqi, 2020). So it can happen unknowingly that an infected person can transmit it to others during that grace period. Therefore it is necessary to take Action for people who have recently traveled abroad or had close contact with patients to isolate themselves inside the house first for approximately 2 weeks.

To analyze the dynamics of the spread of this disease, one of the techniques is to use mathematical models. Where mathematical models can be formulated based on the characteristics of the disease. As previously outlined, for *Coronavirus Disease (COVID-19)* disease the early symptoms are difficult to see, it takes time to know the progress of the patient's state. Therefore, a mathematical model formulated to determine the spread of the Corona virus is needed.

One of them is the SEIR epidemic model. The SEIR model is a mathematical model that can describe the pattern of spread of a disease that affects humans. The SEIR model can describe the pattern of disease spread fromsusceptible to exposed groups which then becomeinfected. If infected survive and recover, then enter the recoveredgroup(Hetchote, 1989 in Saputro, 2017). In this study, the population was divided into susceptible groups (S), namely individuals who aresusceptible to disease, exposed (E) namely individuals who have been attacked by the disease but have not been able to transmit it, infected (I) which is an individual who has been attacked and can transmit the disease and recovered (R) which is an individual who has recovered from the disease.

To be able to analyze requires an appropriate method so that the results obtained show accuracy. One of the methods that can be used is the Euler Method. The Euler method is one of the numerical methods used to solve the first degree differential equation with a given initial value. Furthermore, there is the Heun method which can also be used as a way to solve equations analytically and numerically. These two methods have something in common that is a numerical way or procedure for solving ordinary differential equations with known initial values.

This is now the New Normal era. Where all human activities are starting to recover as before, but are still limited by the implementation of Health Protocols (PROKES), namely wearing masks, washing hands with soap, avoiding crowds, maintaining distance, and limiting mobility (Aulia, 2021). The state of the corona pandemic is also still up and down. People still need to run the 5 M's. The vaccination process is also ongoing. With vaccinations, we hope that this pandemic will end. Meanwhile, the purpose of the study is to find out the completion of the numerical solution of the SEIR epidemic at the rate of *Coronavirus Disease (COVID-19)* disease using the Euler method and the Heun method, To find out the design of a mathematics learning plan in Senior High School that is in accordance with the concept of the numerical method, To find out the interpretation of the model by conducting simulations in order to see the dynamics of the spread of the disease.

Method

In analyzing the spread of Covid-19 disease after the new normal, amathematical model of Covid-19 disease will be developed using the *SEIR* type, as shown below:

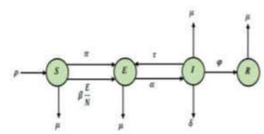

Figure 3.2. SEIR Type Mathematical Modeling

The stages of this research are as follows: (1) Literature Study at this stage researchers conduct studies on COVID-19 modeling from various journals and seek the latest information about COVID-19 on the WHO website and the COVID-19 Control Committee, (2) Making Mathematical Models on Mathematical Models of the spread of COVID-19 disease type *SEIR* obtained from the development of *SEI* type mathematical models conducted by Abrahan and San Rikardus in 2015, This stage will be compiled assuming the formation of a mathematical model of the spread of the COVID-19 SEIR disease by adding influencing factors such as locdown and quarantine which is continued by compiling a flowchart of the spread of Covid-19. Based on the flow of the spread of covid-19, a mathematical model of the case studied will be obtained. The results of the development of the model will be studied in this study, (3) Model Analysis at this stage The model obtained will be searched for equilibrium points and basic reproductive numbers. Furthermore, the relationship between the basic reproductive number and the existence of equilibrium points and their stability is sought. The equilibrium point stability is used to analyze the behavior of the formed model solution, (4) Simulation at this stage Simulation is carried out by assigning values for each parameter according to the analyzed conditions, based on the theorem described above, numericalimulation is performed to provide a geometric picture of the solution and to support the theorem obtained. The simulation results are analyzed and described, so that an overview of the SEIR model analysis for the spread of Covid-19 disease after the new normal using the Euler method and the MATLAB-assisted Heun method will be obtained, (5) Conclusions and at this stage Furthermore, recommendations from this study will be compiled on how efforts can be made to control the COVID-19 disease outbreak based on the model analysis carried out.

The location of the study was carried out at a medan state university with the subject and object of research on the number of Covid-19 sufferers in North Sumatra in 2020-2021 through an initial data collection instrument

data collection was carried out from Covid-19 examination data from a number of laboratories under the Health Research and Development Agency (Balitbangkes) especially for North Sumatra with data collection techniques To draw a conclusion, the data obtained needs to be compiled and then processed through MATLAB in order to get a conclusion to be described.

Results and Discussion

The SEIR model analysis research on the spread of Covid-19 disease after the new normal with the Euler method and the Heun method through the help of MATLAB was carried out with 5 stages of completion with analytical studies and numerical approaches. The object of this study is the SEIR mathematical model.

1. Literature Studies

From several cases that have been identified and determined assumptions related to what variables will be involved in the formation of a mathematical model according to the case of Covid_19.Basedon the literature that has been analyzed, it can be seen that the spread of the disease can be modeled in the form of SEIR consisting of four compartments, namely the subpopulation Susceptible (S), Exposed (E), Infected (I) and Recovered (R) which we can describe as follows:

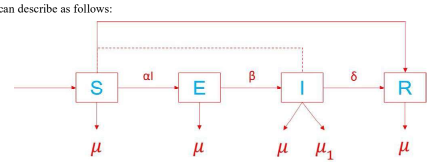

Figure 1. SEIR Covid_19 MODEL

The SEIR model in figure 1can be expressed in a system of differential equations for the following SEIR model:

$$\frac{dS}{dt} = \mu N - \left(\frac{\alpha I}{N} + \mu + v\right) S \quad (1)$$

$$\frac{dE}{dt} = \frac{\alpha I S}{N} - (\beta + \mu)\, E \quad (2)$$

$$\frac{dI}{dt} = \beta E - (\mu_1 + \delta + \mu)\, I \quad (3)$$

$$\frac{dR}{dt} = \delta I + vS + \mu R \quad (4)$$

Table 2. Model variables and parameters

Variable	Information
T: Time	
S(t): Population susceptible to disease at time t	
E(t): Population exposed to the disease at time t	
I(t): Population infected against the disease at time t	
R(t): Population recovered from disease at time t	
N(t) : Population$N(t) = S(t) + (E(t) + I\,(t) + R\,(t)$	
μ	: Birth/death rate
α: The rate of contact of Susceptible individuals with Infected individuals	
β	: Virus activation rate
μ_1	: The rate of death due to Covid_19
δ	: Recovery Rate of Infected Individuals Covid_19
v	: Vaccine Administration Rate

Based on the table above, the variable t states the time of observation starting in what year and until what year the observation of the object begins. The variable S (t) represents a variable that is susceptible to disease over a period of time. The variable E (t) represents the variable exposed to the object of the disease at a given period of time. Variable I (t) represents the number of people infected with the disease at any given time. The variable R (t) expresses the number of people who recovered from the disease at any given time. The variable N (t) expresses the number of the entire population be it the number of people susceptible to the disease plus the number of people exposed to the disease plus the number of infected people plus the number of people who recovered. The variableμ expresses the number of deaths affected by the disease. The variableα states the number of susceptible aims to transfer the number of susceptible to the amount recovered directly without becoming exposed or infected. Variableβstates variable that serve to control how quickly an individual moves from vulnerable to an exposed or infected individual. The variableμ_1 states the rate of death resulting from Covid_19 disease. The variableδ expresses the cure rate of an infected individual covid_19. Variable$v$ states or describe about vaccination.

2. Mathematical Model Making
   1. The object used is seen as a real problem
   2. Observing the factors affecting the problem
   3. Determine significant factors and can affect the object of the problem.
   4. Analyzed mathematical relationships and significant factors based on the applicable rules
   5. Determining the solution and its Mathematical model
   6. Tested whether the solution provided is possible

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3. Model Analysis

Euler method

The Euler method is one of the early numerical methods that can solve differential equations with discrete time (Elaydi, 2005: 20).

$$\frac{dx}{dt} = x'(t) = f(x(t), t), \quad t > t_0 \qquad (2.1)$$
$$x(t_0) = x_0$$

The application of Euler's method in solving(2.2) equations begin with applying the Taylor series:

$$x(t+h) = x(t) + hx'(t) + \frac{1}{2!}h^2 x''(t) + \cdots \qquad (2.3)$$

If $R_1(t) = \frac{1}{2!}h^2 x''(\ell)$ with $\ell \epsilon (t, t+h)$, then the(2.3) equation is obtained:

$$x(t+h) = x(t) + hx'(t) + R_1(t) \qquad (2.4)$$

If there is such a positive number, then $M|x''(t)| \le M, \forall t \epsilon (t_0, t_f)$ is obtained:

$$|R_1(t)| \le \frac{1}{2}Mh^2, \qquad R_1(t) = 0(h^2)$$

If the (2.2)equation is substituted into the(2.4) equation, then it is obtained:

$$x(t+h) = x(t) + hf(x(T), t) + R_1(t) \qquad (2.5)$$

with $R_1(t)$ is a local truncation error. The value of $R_1(t)$ is small enough because the taken value h is quite small. When the value of $t = t_i$ with $t_i = t_0 + ih, i = 1 : I$ and $I = (t_f - t_0)/h$ is the number of h steps that is not more than $t = t_f$ with $t = t_i$ for $i < I$ in the(2.5) equation obtained:

$$x(t_{i+1}) = x(t_i) + hf(x(t_i), t_i) + R_1(t_i), \quad i = 0 : I - 1 \qquad (2.6)$$

with the initial conditions $x(t_0) = x_0$.

Because the value of $R_1(t) = 0(h^2)$ is small enough (with taken $h = t_{i+1} - t_i$ that small enough), so that when ignored obtained the Euler method is:

$$x_{i+1} = x_i + hf(x_i, t_i), \quad i = 0,1,2,3, ... \qquad (2.7)$$

Based on the (2.7)equation, if given three non-free variables, namely:

$$x'(t) = p(x(t), y(t), z(t), t)$$
$$y'(t) = q(x(t), y(t), z(t), t)$$
$$z'(t) = r(x(t), y(t), z(t), t)$$
$$x(t_0) = x_0, \quad y(t_0) = y_0, \quad z(t_0) = z_0$$

then by applying the Euler method to the system of such equations is obtained:

$$x_{i+1} = x_i + hp(x_1, y_1, z_1, t_i) \qquad (2.8)$$
$$y_{i+1} = y_i + hq(x_1, y_1, z_1, t_i) \qquad (2.9)$$
$$z_{i+1} = z_i + hr(x_1, y_1, z_1, t_i) \qquad (2.10)$$

with $h = t_{i+1} - t_i, \quad x(t_0) = x_0, \quad y(t_0) = y_0, \quad z(t_0) = z_0$

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Heun Method

The Heun method is one of the numerical methods in order to solve those that have an initial value problem in differential equations. The Heun method is also called the Euler method repair. In the Heun method, the initial approximate solution is taken from the solution obtained from the Euler method called the *predictor* and corrected by the heun method called the corrector. Given a first-order differential equation that has initial conditions $y(t_0) = y_0$

$$y'(t) = f(y(t), t) \qquad (2.11)$$

If the(2.11) equation is integrated its two internodes with the constraints of t_i until t_{i+1} and $h = t_{i+1} - t_i$ is obtained:

$$\int_{t_i}^{t_{i+1}} y'(t)\,dt = \int_{t_i}^{t_{i+1}} f(y(t), t)\,dt$$

$$y(t)|_{t_i}^{t_{i+1}} = \int_{t_i}^{t_{i+1}} f(y(t), t)\,dt$$

$$y(t_{i+1}) - y(t_i) = \int_{t_i}^{t_{i+1}} f(y(t), t)\,dt$$

$$y_{i+1} - y_i = \int_{t_i}^{t_{i+1}} f(y(t), t)\,dt$$

$$y_{i+1} = y_i + \int_{t_i}^{t_{i+1}} f(y(t), t)\,dt \qquad (2.12)$$

$\int_{t_i}^{t_{i+1}} f(y(t), t)\,dt$ can be solved using the rules of trapezium, obtained:

$$\int_{t_i}^{t_{i+1}} f(y(t), t)\,dt = \frac{[f(y_i, t_i) + f(y_{i+1}, t_{i+1}]}{2}(t_{i+1} - t_i)$$

or

$$\int_{t_i}^{t_{i+1}} f(y(t), t)\,dt = \frac{h}{2}[f(y_i, t_i) + f(y_{i+1}, t_{i+1})] \qquad (2.13)$$

On the(2.13) equation substituted to the(2.12) equation obtained:

$$y_{i+1} = y_i + \frac{h}{2}[f(y_i, t_i) + f(y_{i+1}, t_{i+1})] \qquad (2.14)$$

The(2.14) equation is called the Heun method equation, with: y_{i+1} is the present approach and y_i is the previous near, with($i = 0,1,2,3, \dots, n$.The value of y_{i+1} is the initial approximate solution (predictor) of the Heun method that obtained by the Euler method. The Heun equation so that:

Predictor:

$$y_{i+1}^{(0)} = y_i + hf(y_i, t_i) \qquad (2.15)$$

Corrector:

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$$y_{i+1} = y_i + \frac{h}{2}[f(y_i, t_i) + f(y_{i+1}^{(0)}, y_{i+1})] \qquad (2.16)$$

Based on the description of the Heun method above, then if given a system of first-order differential equations with three non-free variables:

$$x'(t) = p(x(t), y(t), z(t), t)$$
$$y'(t) = q(x(t), y(t), z(t), t)$$
$$z'(t) = r(x(t), y(t), z(t), t)$$
$$x(t_0) = x_0, \quad y(t_0) = y_0, \quad z(t_0) = z_0$$

with $h = t_{i+1} - t_i$, then the equation of the Heun method for the system of equations is:

Predictor:

$$x_{i+1}^{(0)} = x_i + hp(x_i, y_i, z_i, t_i) \qquad (2.18)$$
$$y_{i+1}^{(0)} = y_i + hq(x_i, y_i, z_i, t_i) \qquad (2.19)$$
$$z_{i+1}^{(0)} = z_i + hr(x_i, y_i, z_i, t_i) \qquad (2.20)$$

Corrector:

$$x_{i+1} = x_i + \frac{h}{2}[p(x_i, y_i, z_i, t_i) + p(x_{i+1}^{(0)}, y_{i+1}^{(0)}, z_{i+1}^{(0)}, t_{i+1})] \qquad (2.21)$$
$$y_{i+1} = y_i + \frac{h}{2}[q(x_i, y_i, z_i, t_i) + q(x_{i+1}^{(0)}, y_{i+1}^{(0)}, z_{i+1}^{(0)}, t_{i+1})] \qquad (2.22)$$
$$z_{i+1} = z_i + \frac{h}{2}[r(x_i, y_i, z_i, t_i) + r(x_{i+1}^{(0)}, y_{i+1}^{(0)}, z_{i+1}^{(0)}, t_{i+1})] \qquad (2.23)$$

with $i = 0,1,2,3,4, \dots$

4. Model Simulation

Simulation of the post-new normal Covid-19 disease spread model using the Euler method and the MATLAB-Assisted Heun method using parameters from several studies. Systematically displayed on Table 2.

Table 3. Research Parameters

Initial Conditions and Parameters	Initial Condition/Parameter Value	
	Simulation I	Simulation II
N_h	273879750	269603400
S_h	273727072	269463225
I_h	4262720	743198
I_i	4292	8074
R_h	4114334	611097
$x(t_0) = x_0$	0.999442536	0.99948007
$y(t_0) = y_0$	0.015564203	0.002756634
$z(t_0) = z_0$	0.0000156799	0.000029948
μ_h	0.000526121	0.000082113
β_h	0.999442536	0.99948007
γ	0.001006869	0.010863861
δ_h	1.036065618	1.216170264
φ_h	0.001043182	0.013212305

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A. Completion of the Covid 19 Disease SEIR Model with the Euler Method

$$x_{i+1} = x_i + h(\mu_h - \beta_h x_i - \gamma\beta_h x_i y_i - \mu_h x_i)$$
$$y_{i+1} = y_i + h(\beta_h x_i - (\mu_h + \delta_h)y_i)$$
$$z_{i+1} = z_i + h(\gamma\beta_h x_i y_i - (\mu_h + \varphi_h)z_i)$$

with $h = t_{i+1} - t_i, x(t_0) = x_0, y(t_0) = y_0, z(t_0) = z_0$ and $i = 0,1,2,3,4 \dots$

Simulation I

Applying the first data (Simulation I) with $h = 0.1$, and $i = 0, 1, 2, 3, \dots$ on theequation x_{i+1}, y_{i+1},and z_{i+1} will be obtained a figure on the matlab or solution completion graph of the Covid 19 transmission system of the SEIR model using the first data that has been calculated.

$$x_{i+1} = x_i + h(0.000526121 - 0.999442536x_i - 0.001006307x_i y_i - 0.000526121x_i)$$
$$y_{i+1} = y_i + h(0.999442536x_i - (0.000526121 + 1.036065618)y_i)$$
$$z_{i+1} = z_i + h((0.001006869)(0.999442536)x_i y_i - (0.000526121 + 0.001043182)z_i$$

on x_{i+1} for $i = 0$

In this simulation, if given about 30 days, an epidemic process will occur in each population. The recovered population will increase and stabilize with the value of $\gamma = 0.001006869$, and the vulnerable population will decline, but under certain conditions it will become vulnerable again. Under these circumstances it is assumed that no population is affected by Covid_19 in the infected and recovered population.

Simulation II

Applying the first data (Simulation I) with $h = 0.1$, and $i = 0, 1, 2, 3, \dots$on the equation x_{i+1}, y_{i+1},and z_{i+1} will be obtained a figure on the matlab or solution completion graph of the Covid 19 transmission system of the SEIR model using the first data that has been calculated.

$$x_{i+1} = x_i + h(0.000082113 - 0.99948007x_i - (0.010863861)(0.99948007)x_i y_i - 0.000082113x_i)$$
$$x_{i+1} = x_i + h(0.000082113 - 0.99948007x_i - 0.010858212x_i y_i - 0.000082113x_i)$$
$$y_{i+1} = y_i + h(0.99948007x_i - (0.000082113 + 1.216170264)y_i)$$
$$y_{i+1} = y_i + h(0.99948007x_i - 1.216252377y_i)$$
$$z_{i+1} = z_i + h((0.010863861)(0.99948007)x_i y_i - (0.000082113 +$$

$0.013212305)z_i)$

$z_{i+1} = z_i + h(0.010858212\, x_i y_i - 0.013294418 z_i)$

on x_{i+1} for $i = 0$

In this simulation, if given about 30 days, an epidemic process will occur in each population. The recovered population will increase and stabilize with the value of $\gamma = 0.010863861$, and the vulnerable population will decline, but under certain conditions it will become vulnerable again. Under these circumstances it is assumed that no population is affected by Covid_19 in the infected and recovered population.

B. Completion of the Covid 19 Disease SEIR Model with the Heun Method

Predictor:

$$x_{i+1}^{(0)} = x_i + h(\mu_h - \beta_h x_i - \gamma \beta_h x_i y_i - \mu_h x_i)$$
$$y_{i+1}^{(0)} = y_i + h(\beta_h x_i - (\mu_h + \delta_h) y_i)$$
$$z_{i+1}^{(0)} = z_i + h(\gamma \beta_h x_i y_i - (\mu_h + \varphi_h) z_i)$$

Corrector:

$$x_{i+1} = x_i + \frac{h}{2}\left[(\mu_h - \beta_h x_i - \gamma \beta_h x_i y_i - \mu_h x_i) + \left(\mu_h - \beta_h x_{i+1}^{(0)} - \gamma \beta_h x_{i+1}^{(0)} y_{i+1}^{(0)} - \mu_h x_{i+1}^{(0)}\right)\right]$$
$$y_{i+1} = y_i + \frac{h}{2}\left[(\beta_h x_i - (\mu_h + \delta_h) y_i) + \left(\beta_h x_{i+1}^{(0)} - (\mu_h + \delta_h) y_{i+1}^{(0)}\right)\right]$$
$$z_{i+1} = z_i + \frac{h}{2}\left[(\gamma \beta_h x_i y_i - (\mu_h + \varphi_h) z_i) + \left(\gamma \beta_h x_{i+1}^{(0)} y_{i+1}^{(0)} - (\mu_h + \varphi_h) z_{i+1}^{(0)}\right)\right]$$

With $i = 0,1,2,3,4, \ldots$ and $h = 0.1$

Simulation I

The application of the Heun method to the *predictor* equation is $x_{i+1}^{(0)}, y_{i+1}^{(0)}$, and $z_{i+1}^{(0)}$ by constructing the model according to the *corrector* equation x_{i+1}, y_{i+1}, and z_{i+1}

to $i = 0$.

Predictor:

$$x_1^{(0)} = x_0 + h(0.000526121 - 0.999442536\, x_0 - (0.001006869)(0.999442536) x_0 y_0 - 0.000526121 x_0)$$
$$x_1^{(0)} = 0.999442536 + 0.1(0.000526121 - 0.999442536(0.999442536) - 0.001006307(0.999442536)(0.015564203) - 0.000526121(0.999442536))$$
$$x_1^{(0)} = 0.999442536 + 0.1(0.000526121 - 0.998885382 - 0.000015653 - 0.000525827)$$
$$x_1^{(0)} = 0.999442536 + 0.1(-0.998900741)$$
$$x_1^{(0)} = 0.999442536 - 0.0998900741$$
$$x_1^{(0)} = 0.8995524619$$

$$y_1^{(0)} = y_0 + h(0.999442536\, x_0 - (0.000526121 + 1.036065618) y_0)$$
$$y_1^{(0)} = 0.015564203 + 0.1(0.999442536(0.999442536) - (1.036591739)(0.015564203))$$
$$y_1^{(0)} = 0.015564203 + 0.1(0.998885382 - 0.016133724)$$
$$y_1^{(0)} = 0.015564203 + 0.1(0.982751658)$$
$$y_1^{(0)} = 0.015564203 + 0.0982751658$$
$$y_1^{(0)} = 0.1138393688$$

$$z_1^{(0)} = z_0 + h((0.001006869)(0.999442536) x_0 y_0 - (0.000526121 + 0.001043182) z_0)$$
$$z_1^{(0)} = 0.0000156799 + 0.1(0.001006307(0.999442536)(0.015564203) - 0.001569303(0.0000156799))$$
$$z_1^{(0)} = 0.0000156799 + 0.1(0.000015653 - 0.000000024)$$
$$z_1^{(0)} = 0.0000156799 + 0.1(0.000015629)$$
$$z_1^{(0)} = 0.0000156799 + 0.0000015629$$
$$z_1^{(0)} = 0.0000172428$$

In this condition, it is considered that no population has been affected by Covid 19 disease in the infected and recovered population.

Simulation II

The application of the Heun method to the *predictor* equation is $x_{i+1}^{(0)}, y_{i+1}^{(0)}$, and $z_{i+1}^{(0)}$ by constructing the model according to the *corrector* equation x_{i+1}, y_{i+1}, and z_{i+1}

to $i = 0$.

Predictor:

$$x_1^{(0)} = x_0 + h(0.000082113 - 0.99948007\, x_0 - (0.010863861)(0.99948007) x_0 y_0 - 0.000082113\, x_0)$$
$$x_1^{(0)} = 0.99948007 + 0.1(0.000082113 - 0.99948007(0.99948007) - 0.010858212(0.99948007)(0.002756634) - 0.000082113(0.99948007))$$
$$x_1^{(0)} = 0.99948007 + 0.1(0.000082113 - 0.99896041 - 0.000029916 - 0.00008207)$$
$$x_1^{(0)} = 0.99948007 + 0.1(-0.998990283)$$
$$x_1^{(0)} = 0.99948007 - 0.0998990283$$
$$x_1^{(0)} = 0.8995810417$$

$$y_1^{(0)} = y_0 + h(0.99948007\, x_0 - (0.000082113 + 1.216170264) y_0)$$
$$y_1^{(0)} = 0.002756634 + 0.1(0.99948007(0.99948007) - 1.216252377(0.002756634))$$
$$y_1^{(0)} = 0.002756634 + 0.1(0.99896041 - 0.003352762)$$

$$y_1^{(0)} = 0.002756634 + 0.1(0.99543279)$$
$$y_1^{(0)} = 0.002756634 + 0.099543279$$
$$y_1^{(0)} = 0.102299913$$
$$z_1^{(0)} = z_0 + h((0.010863861)(0.99948007) x_0 y_0 - (0.000082113 + 0.013212305) z_0)$$
$$z_1^{(0)} = 0.000029948 + 0.1(0.010858212(0.99948007)(0.002756634) - 0.013294418(0.000029948))$$
$$z_1^{(0)} = 0.000029948 + 0.1(0.000029916 - 0.000000398)$$
$$z_1^{(0)} = 0.000029948 + 0.1(0.000029518)$$
$$z_1^{(0)} = 0.000029948 + 0.0000029518$$
$$z_1^{(0)} = 0.0000328998$$

In this condition, it is considered that no population has been affected by Covid 19 disease in the infected and recovered population.

5. **Analysis of Simulation Results**

Based on the calculation results from the numerical method used previously, it can be seen and compared for the values of x(t), y(t) and z(t) for each simulation as follows:

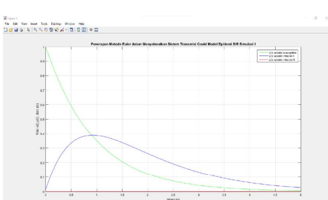

Figure 2. Simulation Results I Using Euler's Method

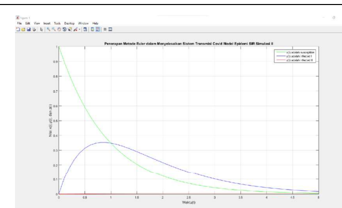

Figure 3. Simulation Results II Using Euler Method

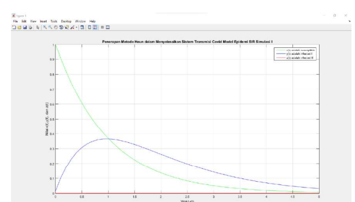

Figure 4. Simulation Results I Using Heun Method

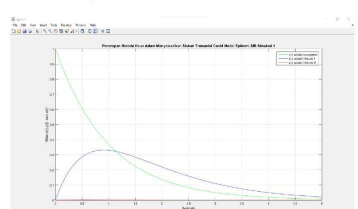

Figure 5. Simulation Results II Using Heun Method

From the results of calculations using the numerical method above, it can be concluded: First, if many people are infected with Covid_19, the number of people from the entire population who are susceptible to the disease will also decrease or decrease which results in population members being infected over time, be it the infected population or the population given the vaccine, in other words, all populations will be infected. Secondly, the difference in the solution of the calculation results between Euler and Heun, both of which this method is calculated with the help of Matlab software, is very small and almost imperceptible difference. If you compare the calculation amount of the euler method is greater than the Heun method. From the calculations of the two methods with the help of Matlab, it can be seen that many humans are infected with Covid_19.

Conclusion

The numerical solution of the SEIR epidemic at the rate of *Coronavirus Disease (COVID-19)* using the Euler method and the Heun method with MATLAB assistance can be used to solve the spread of Covid_19 disease after the new normal that has been modeled. Based on the discussion, it can be concluded that the Euler method and the Heun method.

The learning of mathematics in high school that is in accordance with the concept of numerical methods is through derivatives and linear programs.

The dynamics of the spread of the disease using numerical calculations can be expressed by assuming that many people are infected with Covid_19, then the number of people from the entire population who are susceptible to the disease will also decrease or decrease which results in members of the population will be infected over time, be it the infected population or the population given the vaccine, in other words, all populations will be infected.

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