Modelling the Impact of Rumors on Student Attendance in College Classes

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

OF

MASTER OF SCIENCE

IN

MATHEMATICS

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MAY, 2023

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DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

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We, Anshul, 2K21/MSCMAT/07 & Seema, 2K21/MSCMAT/46 students of M.Sc. Mathematics, hereby declare that the project Dissertation titled " Modelling the Impact of Rumors on Student Attendance in College Classes " which is submitted by me to the Department of Applied Mathematics Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Science, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

We hereby certify that the Project Dissertation titled " **Modelling the Impact of Rumors on Student Attendance in College Classes** " which is submitted by Anshul, Roll no. 2K21/MSCMAT/07 & Seema, Roll no. 2K21/MSCMAT/46 [Department of Applied Mathematics], Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Science, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: New Delhi **Dr. Nilam**

Date: **SUPERVISOR**

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ABSTRACT

Rumors are an inherent aspect of human communication and can profoundly influence individuals' attitudes and behaviors. Particularly in a college environment, rumors can wield a significant influence on student attendance in classes.

This research paper aims to delve into the repercussions of rumors on student attendance in college classrooms. Rumors are a frequent occurrence on college campuses and possess the power to shape students' behaviors and perceptions. To comprehensively analyze the impact of rumors on student attendance, we propose a mathematical model known as the SVNIR model.

The SVNIR model categorizes the population into four compartments: susceptible (S), students in proximity who have been exposed to the rumor (V), students outside the vicinity who have heard the rumor (N), and students who have attended class (R).

The study's findings demonstrate that rumors can wield a considerable impact on student attendance. Negative rumors result in a decline in attendance, while positive rumors lead to an increase in attendance.

Overall, this research underscores the significance of comprehending the influence of rumors on student attendance in college classes. It introduces a fresh and innovative approach by employing the SIR model to depict the dynamics of rumors. This accentuates the importance of recognizing the role of rumors in shaping student attendance in college classes. Educators should be cognizant of the potential consequences of rumors on student attendance and proactively take measures to address them. These measures may include providing accurate information and fostering trust among students.

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Signature

Anshul

Seema

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ABBREVATIONS USED

ODEs: Ordinary Differential Equations

SIR: Susceptible (S), Infected (I), and Recovered (R)

SVNIR: Susceptible (S), Students in vicinity who have heard the rumor (V), Students not in the vicinity who have heard the rumor (N), Infected (I) and Students who have attended class (R)

Ode45: Command in MATLAB

CHAPTER 1

INTRODUCTION TO STABILITY

1.1 What is stability in general?

In general, stability refers to the ability of a system or object to remain balanced or unchanged despite external forces or disturbances.

For instance, when we talk about the stability of a physical object, it means that the object can maintain its position without toppling over or collapsing when it is subjected to external forces like wind or gravity. Similarly, in the context of systems such as financial markets or ecological communities, stability implies the capacity to withstand changes or disruptions and continue functioning within established parameters.

Stability is a crucial concept in various fields, including physics, engineering, economics, and ecology. It serves as a measure of the reliability or robustness of a system and is a fundamental consideration when designing systems and processes that are intended to be long-lasting and resistant to change.

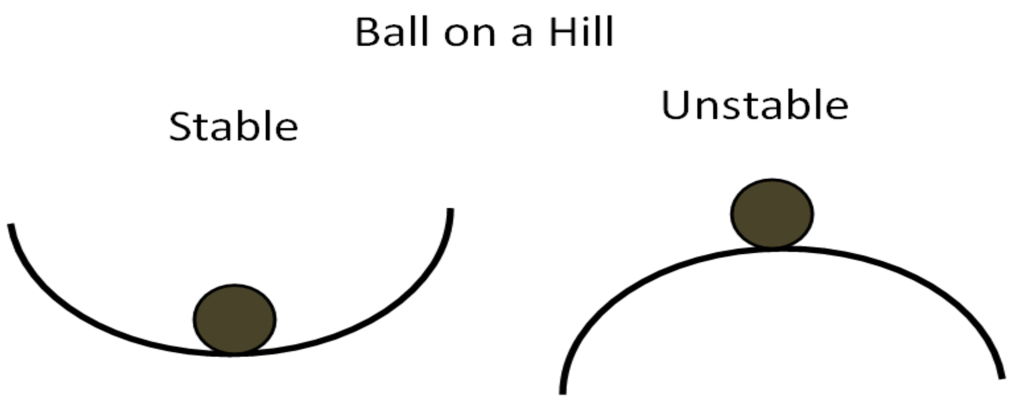

Figure 1

1.2 Stability in mathematical modelling

In the realm of mathematical modelling, stability pertains to the behavior of a mathematical system or model as time advances.

It indicates whether the solution to a mathematical equation or a set of equations remains bounded and avoids excessive or erratic behavior. Stability is particularly significant when dealing with dynamic systems, wherein variables undergo continuous changes governed by mathematical equations or rules. Mathematical models serve as tools to simulate and analyze various phenomena across diverse domains, including physics, engineering, economics, and biology.

1.3 Stability Theorem

The stability theorem states the following for an autonomous differential equation of the form $\frac{dx}{dt} = f(x)$ where $x(t) = x$ is an equilibrium point $(i.e., f(x) = 0)$:

1. If the derivative of f(x) evaluated at the equilibrium point, $f'(x)$, is negative $(f'(x) < 0)$, then the equilibrium $x(t) = x$ is stable.
2. If the derivative of f(x) evaluated at the equilibrium point, $f'(x)$, is positive $(f'(x) < 0)$, then the equilibrium $x(t) = x$ is unstable.

In simpler terms, the stability of an equilibrium point in an autonomous differential equation is determined by the sign of the derivative of the function f(x) at that point.

If the derivative is negative, the equilibrium is stable, meaning small perturbations around the equilibrium will eventually return to it. Conversely, if the derivative is positive, the equilibrium is unstable, implying that small perturbations will cause the system to move away from the equilibrium. This stability theorem provides a valuable criterion to analyze the behavior of autonomous differential equations and understand the stability properties of their equilibria.

CHAPTER 2

LYAPUNOV FUNCTIONS

2.1 Lyapunov functions

Lyapunov functions, named after Aleksandr Lyapunov, are scalar functions used to analyze and verify the stability of equilibria in ordinary differential equations (ODEs). They play a crucial role in dynamical system stability and control theory. A similar concept to Lyapunov functions can be found in the theory of general state-space Markov chains.

Used to demonstrate the stability of an equilibrium point.

Let V(X) be a continuously differentiable function defined in a neighbourhood U of the origin. If the following conditions are satisfied, the function V(X) is referred to as the Lyapunov function for an autonomous system X' = f(x):

1. $V(X) > 0$ for all $X \in U\{0\}$: The Lyapunov function is positive for all points in the neighbourhood U except at the origin.
2. $\frac{dV}{dt} \leq 0$ for all X ∈ U: The derivative of the Lyapunov function with respect to time is less than or equal to zero for all points in the neighborhood U.
3. V (0) = 0: The Lyapunov function evaluates to zero at the origin.

Lyapunov functions provide a powerful tool for studying the stability properties of equilibrium points in autonomous systems. By constructing or finding appropriate Lyapunov functions, it becomes possible to analyze and establish the stability or instability of equilibria in ODEs.

CHAPTER 3

ROUTH HURWITZ CRITERION

3.1 Routh Hurwitz Criterion

The Routh-Hurwitz criterion is a mathematical technique employed in the analysis of linear time-invariant systems in the realm of mathematical modeling. It serves as a tool to ascertain the stability of a system by examining the coefficients present in its characteristic polynomial.

The Routh-Hurwitz criterion is a valuable tool in mathematical modeling as it provides a means to assess the stability of a system without the need to explicitly solve for its roots or poles. This criterion offers a practical and efficient approach to analyze and design mathematical models in diverse fields, including control systems, signal processing, and circuit analysis.

By utilizing the Routh-Hurwitz criterion, stability analysis becomes more accessible and less computationally intensive. Instead of solving for the roots or poles of the system, which can be complex and time-consuming for higher-order systems, the criterion allows for stability determination by examining the coefficients of the characteristic polynomial.

This approach significantly simplifies the stability assessment process, making it more practical for real-world applications. Engineers and researchers can rely on the Routh-Hurwitz criterion to evaluate system stability and make informed decisions regarding the design and optimization of mathematical models.

CHAPTER 4

EQUILIBRIUM POINTS

4.1 Equilibrium Points

Equilibrium points, also known as fixed points, are critical points within a dynamical system where the state variables remain constant over time. These points represent stable or stationary configurations of the system.

In the realm of mathematical modelling, equilibrium points play a vital role in analyzing the behavior and stability of dynamic systems. They are determined by setting the derivatives or rates of change of the state variables to zero, resulting in a system of equations that defines the conditions under which the system remains unchanged.

4.2 Equilibrium points can possess various characteristics

1. **Stable equilibrium**: If small perturbations or disturbances occur in the vicinity of a stable equilibrium point, the system will tend to return to that point. In other words, the system is attracted to and remains close to the equilibrium.
2. **Unstable equilibrium:** If small perturbations take place around an unstable equilibrium point, the system will diverge from that point and exhibit significant changes. The system is unable to maintain stability in the presence of disturbances.
3. **Neutral equilibrium**: In certain cases, equilibrium points can be neutral, whereby small perturbations do not lead to significant changes within the system. The system remains in a balanced state without converging towards or diverging from the equilibrium.

Equilibrium points provide invaluable insights into the behavior and stability of mathematical models. They serve as reference states for comprehending the dynamics of the system, analyzing stability properties, and making predictions regarding the system's long-term behavior. To know physical representation, see the figure 2 below:

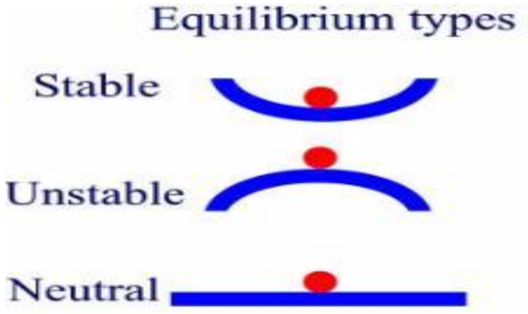

Figure 2

4.3 Equilibrium Points of a Differential Equation

To find equilibrium points of a differential equation, you need to solve the equation for the values of the variables at which the derivative or rate of change of the variables is zero. Let us consider a differential equation of the form $\frac{dx}{dt} = f(x)$

where x represents the variables and f(x) is the function defining their rates of change.

Set the derivative $\frac{dx}{dt} = 0$

Solve the resulting equation for the values of x that satisfy it. This means finding the values of x at which the rate of change is zero.

Example:

Consider the following autonomous differential equation:

$$dy/dt = -2y$$

To find the equilibrium points, we set the derivative equal to zero:

$$dy/dt = 0$$

$$-2y = 0$$

Solving this equation, we find that y = 0. Therefore, the equilibrium point of this differential equation is y = 0.

To analyze the stability of this, we examine the sign of the given derivative for values of y around the equilibrium.

Let's consider a point slightly to the left of y = 0, for example, y = -0.1:

When y = -0.1, the derivative

$$dy/dt = -2(-0.1) = 0.2.$$

Since the derivative is positive, it indicates that for y < 0 (to the left of the equilibrium), the function y is increasing and moving away from the equilibrium point y = 0.

Similarly, if we take a point slightly to the right of y = 0, let's say y = 0.1:

When y = 0.1, the derivative

$$dy/dt = -2(0.1) = -0.2.$$

In this case, the derivative is negative, implying that for y > 0 (to the right of the equilibrium), the function y is decreasing and moving away from y = 0.

Based on this analysis, we can conclude that the equilibrium point y = 0 is stable. Any initial condition y(0) that is close to zero will cause the solution to approach and remain at y = 0 as time progresses.

CHAPTER 5

SIR MODEL

5.1 SIR Model

SIR model is a mathematical tool used to analyse the spread of infectious diseases within a population. It divides population into three groups:

susceptible (S), infected (I), and recovered (R). This model assumes that individuals can move between these compartments based on certain parameters.

The susceptible (S) compartment represents individuals who have not been infected yet and are susceptible to contracting the disease.

They are at risk of becoming infected if they meet infectious individuals.

The infected (I) group.

They can transmit the infection to susceptible individuals through various means such as close contact, respiratory droplets, or other modes of transmission.

The recovered (R) compartment shows the recovered from the disease and have developed immunity.

They are no longer susceptible to reinfection and cannot transmit the disease to others.

Assumptions:

The total population size is constant throughout the analysis.

Individuals can only transition between the three compartments of susceptible, infected, and recovered.

The model uses differential equations to describe the rates at which individuals move between these groups over time.

The transmission rate (β) and the recovery rate (γ). From SIR, we can gain insights into how diseases spread and how various interventions, such as vaccination campaigns or implementing measures, can impact the course of an epidemic.

It is important to note that the SIR model simplifies reality by assuming homogeneous mixing within the population and neglecting factors such as age, geographic variations, or differences in individual behaviour. Nevertheless, it provides evaluating potential strategies to control and mitigate epidemics.

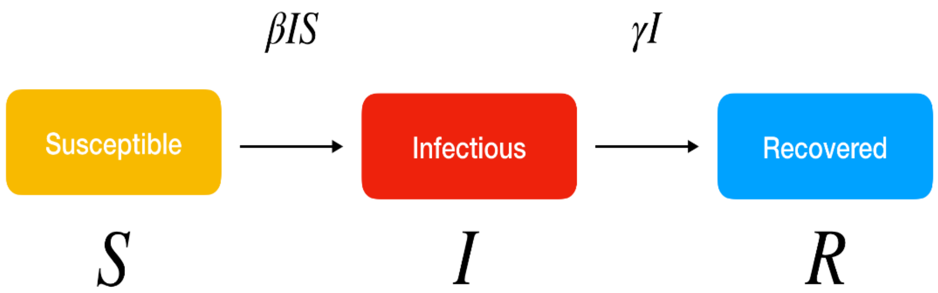

Figure 3

Mathematically,

$$\frac{dS}{dt} = -\beta * S * I$$

$$\frac{dI}{dt} = \beta * S * I - \gamma * I$$

$$\frac{dR}{dt} = \gamma * I$$

In these equations:

$\frac{dS}{dt}$: rate of change of susceptible individuals over time.

$\frac{dI}{dt}$: rate of change of infected individuals over time.

$\frac{dR}{dt}$: rate of change of recovered individuals over time.

These equations capture how the population transitions between the compartments as the disease spreads. They enable us to understand how the number of susceptible individuals decreases as they become infected, how the number of infected individuals increases due to transmission, and how some infected individuals recover and move into the recovered compartment. It's crucial to acknowledge that the SIR model simplifies real-world complexities by assuming uniform mixing within the population and overlooking factors such as age, geographical variations, and individual behaviours. Nonetheless, it serves as a crucial asset for understanding the fundamental of disease transmission and evaluating potential strategies to control and mitigate epidemics.

CHAPTER 6

RUMORS

6.1 What are rumors?

Rumors are a pervasive aspect of human communication, and they can significantly affect individuals' attitudes and behaviours.

College Rumours: In a college setting, rumors can have a significant impact on student attendance in classes. This research paper investigates the impact of rumors on student attendance in college classes. Rumors are a common occurrence on college campuses and can influence students' behavior and perceptions. In this research paper, we propose a mathematical model, the SVNIR model, to study the impact of rumors on student attendance in a college classroom. The SVNIR model divides the population into four compartments: susceptible (S), students in vicinity who have heard the rumor (V), students not in the vicinity who have heard the rumor (N), infected, I represent students who attend class despite rumors (I) and students who have attended class (R)

The findings of the study indicate that rumors can have a significant impact on student attendance, with negative rumors leading to a decrease in attendance and positive rumors leading to an increase in attendance.

The importance of understanding the impact of rumors on student attendance in college classes and provides a novel approach to modelling their dynamics using the SIR model. This highlights the importance of understanding the role of rumors in shaping student attendance in college classes. Educators should be aware of the potential impact of rumors on student attendance and take steps to address them proactively, such as by providing accurate information and building trust with students.

6.2 Problem Definition

The problem we are addressing is how rumors can affect student attendance in college classes. We will consider a scenario where a rumor has started to circulate that a particular class will be cancelled for the day. We will investigate how this rumor can affect student attendance in that class, and what factors can amplify or dampen the impact of the rumor.

6.3 Introduction

The spread of rumors has been a common phenomenon in educational institutions, with many students being influenced by unverified information that can lead to negative consequences. Rumors can have a significant impact on student behavior, including their attendance in class. When students hear rumors about safety concerns or academic issues, they may choose to skip classes or even avoid coming to the institution altogether. This can have a detrimental effect on their academic performance and overall experience in the institution. Therefore, it is essential to understand the factors that influence the impact of rumors on student attendance and develop strategies to mitigate the negative impact.

In this study, we propose an S-V-N-I-R model to investigate the impact of rumors on students' attendance. S represents susceptible students, V represents students who have heard rumors and are in the vicinity, N represents students who have heard rumors but are not in the vicinity, I represents students who attend class despite rumors, and R represents students who attend class and are not susceptible to rumors.

This research paper provides novel insights into the dynamics of rumors and their impact on student attendance in college classes. The use of the SIR model allows us to quantify the effects of rumors on student attendance and identify the factors that can mitigate or exacerbate their impact. The findings of this research have important implications for educators and administrators in higher education settings, providing a useful tool for developing effective strategies to counteract the negative effects of rumors on student attendance.

CHAPTER 7

MODEL FORMULATION

7.1 Model Formulation:

We propose a variation of the classic SIR model called the SVNIR model to study the impact of rumors on student attendance in college classes. The SVNIR model divides the population into four compartments: susceptible (S), students in vicinity who have heard the rumor (V), students not in the vicinity who have heard the rumor (N), and students who have attended class (R). In this model, susceptible individuals are those who have not yet heard the rumor, students in vicinity who heard the rumor (V) are those who heard the rumor from a classmate or friend, students not in vicinity who heard the rumor (N) are those who heard the rumor from sources outside of the classroom,(I) represents students who attend class despite rumors and attended class individuals (R) are those who attended the class despite hearing the rumor.

The model comprises five compartments to describe the dynamics of a rumor within a college setting over time:

1. S(t): This represents the number of students who are susceptible to hearing the rumor at time t. These are students who have not yet been exposed to the rumor.
2. V(t): This represents the number of students in the vicinity who have already heard the rumor at time t. These students are aware of the rumor due to their proximity to others who have heard it.
3. N(t): This represents the number of students who are not in the vicinity but have still heard the rumor at time t. These students have become aware of the rumor through sources outside of the immediate college environment.

4. I(t): This represents the number of infected students at time t who bring the rumor to college. These are students who were previously exposed to the rumor outside of the college setting and have now introduced it to the college community.
5. R(t): This represents the number of recovered students at time t who have attended class. These students were previously infected with the rumor but have recovered and are now actively participating in college activities, including attending classes.

By categorizing the student population into these compartments, we can analyze how the rumor spreads within the college community over time and how various factors, such as student interactions, proximity, and external sources of information, influence its dissemination. It's important to note that this model assumes a simplified scenario specific to the rumor dynamics within a college, and it may not capture all the complexities of real-world situations. However, it serves as a useful framework for studying the basic mechanisms of rumor propagation and evaluating strategies to manage and mitigate its impact within the college environment. We assume that the rumor spreads through contact between students in the same vicinity or through contact between individuals in the same classroom or through online social networks. The dynamics:

$$\frac{dS}{dt} = -\beta SV - \alpha SN$$

$$\frac{dV}{dt} = \beta SV - \omega VI$$

$$\frac{dN}{dt} = \alpha SN - \delta NI$$

$$\frac{dI}{dt} = \omega VI + \delta NI - \frac{\alpha I}{(1+\beta I)} IR$$

$$\frac{dR}{dt} = \frac{\alpha I}{(1+\beta I)} IR$$

Where

α, β is the rate of transmission of the rumor over time

ω is the rate of students leaving the vicinity after hearing the rumor over time

δ is the rate of students leaving the non- vicinity after hearing the rumor over time

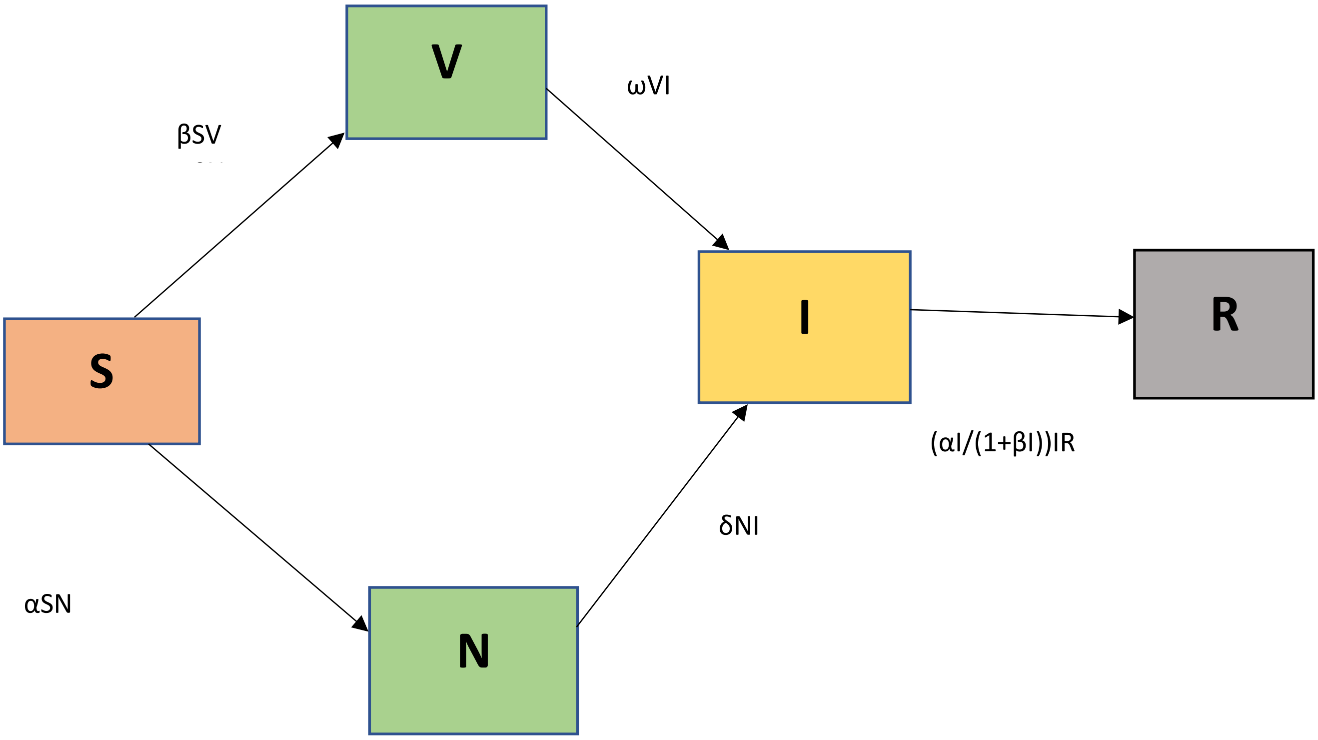

Figure *

SVNIR Model

The SVNIR model provides a useful tool for understanding the dynamics of rumors and their impact on student attendance in college classes. The model can help educators and administrators develop effective strategies to counteract the negative effects of rumors on attendance and improve student performance.

The SVNIR model provides a useful tool for understanding the dynamics of rumors and their impact on student attendance in college classes. The model can help educators and administrators develop effective strategies to counteract the negative effects of rumors on attendance and improve student performance.

CHAPTER 8

NUMERICAL SIMULATION

8.1 NUMERICAL SIMULATION:

CODE:

```
syms p(t) m(t) l(t) q(t) n(t) T Y

Eqns=[diff(p(t),t)==-0.1*p(t)*m(t)-0.2*p(t)*l(t);

diff(m(t),t) == 0.1*p(t)*m(t)-0.4*m(t)*q(t);

diff(l(t),t) == 0.2*p(t)*l(t)-0.5*l(t)*q(t);

diff(q(t),t) == 0.4*m(t)*q(t)+0.5*l(t)*q(t)-(0.1*q(t)/(1+0.2*q(t)))*q(t)*n(t);

diff(n(t),t) == (0.1*q(t)/(1+0.2*q(t)))*q(t)*n(t)];

[DEsys,Subs] = odeToVectorField(Eqns);

DEFcn = matlabFunction(DEsys, 'Vars',{T,Y});

tspan = [0,400];

y0 = [0.08 0.048 0.032 0.03 0.02];

[T,Y] = ode45(DEFcn, tspan, y0);

figure(1)
```

```
plot(T,Y, LineWidth=2)

legend('p(t)','m(t)','l(t)','q(t)','n(t)')

grid

xlabel('Time');

ylabel('Population');

title('Numerical Simulation of a System of DEs');
```

This code defines the initial conditions, time range, step size, and function handle for the system of differential equations. It then uses **ode45** to solve the system and obtain the values of the populations over time.

Finally, it plots the results:

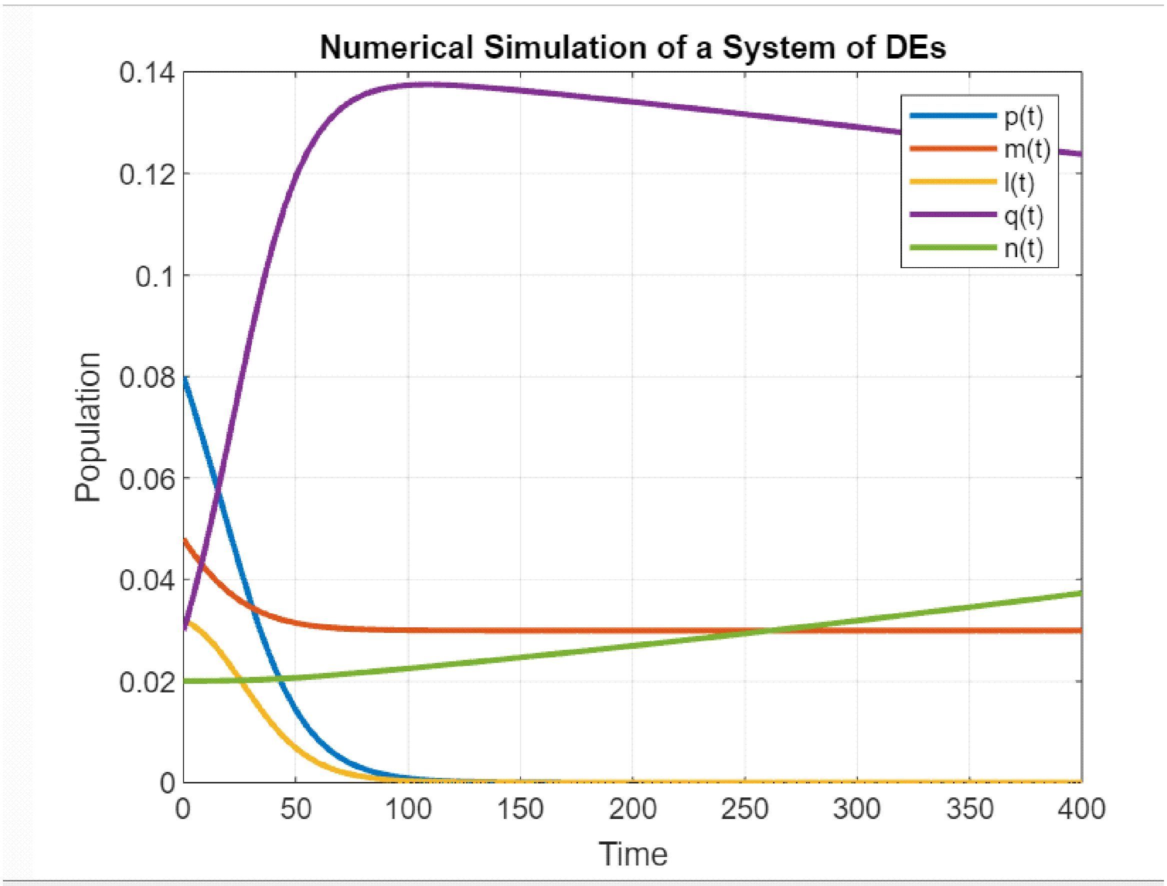

Figure 4

CHAPTER 9

3-D GRAPH

9.1 Vicinity VS Time VS Infected::

CODE:

```
syms p(t) m(t) l(t) q(t) n(t) T Y

Eqns=[diff(p(t),t)==-0.1*p(t)*m(t)-0.2*p(t)*l(t);

diff(m(t),t) == 0.1*p(t)*m(t)-0.4*m(t)*q(t);

diff(l(t),t) == 0.2*p(t)*l(t)-0.5*l(t)*q(t);

diff(q(t),t) == 0.4*m(t)*q(t)+0.5*l(t)*q(t)-(0.1*q(t)/(1+0.2*q(t)))*q(t)*n(t);

diff(n(t),t) == (0.1*q(t)/(1+0.2*q(t)))*q(t)*n(t)];

[DEsys,Subs] = odeToVectorField(Eqns);

DEFcn = matlabFunction(DEsys, 'Vars',{T,Y});

tspan = [0,20000];

y0 = [0.08 0.048 0.032 0.03 0.02];

[T,Y] = ode45(DEFcn, tspan, y0);

figure(1)

plot3(T,Y(:,2),Y(:,4));

xlabel('Time (t)')

ylabel('Infected Individuals (q(t))')
```

zlabel('Vicinity')

legend('\omega1=0.1','\omega1=0.2','\omega1=0.4','\omega1=0.5','\omega1=0.0110')

9.2 Output

The above code plots the 3-D graph as:

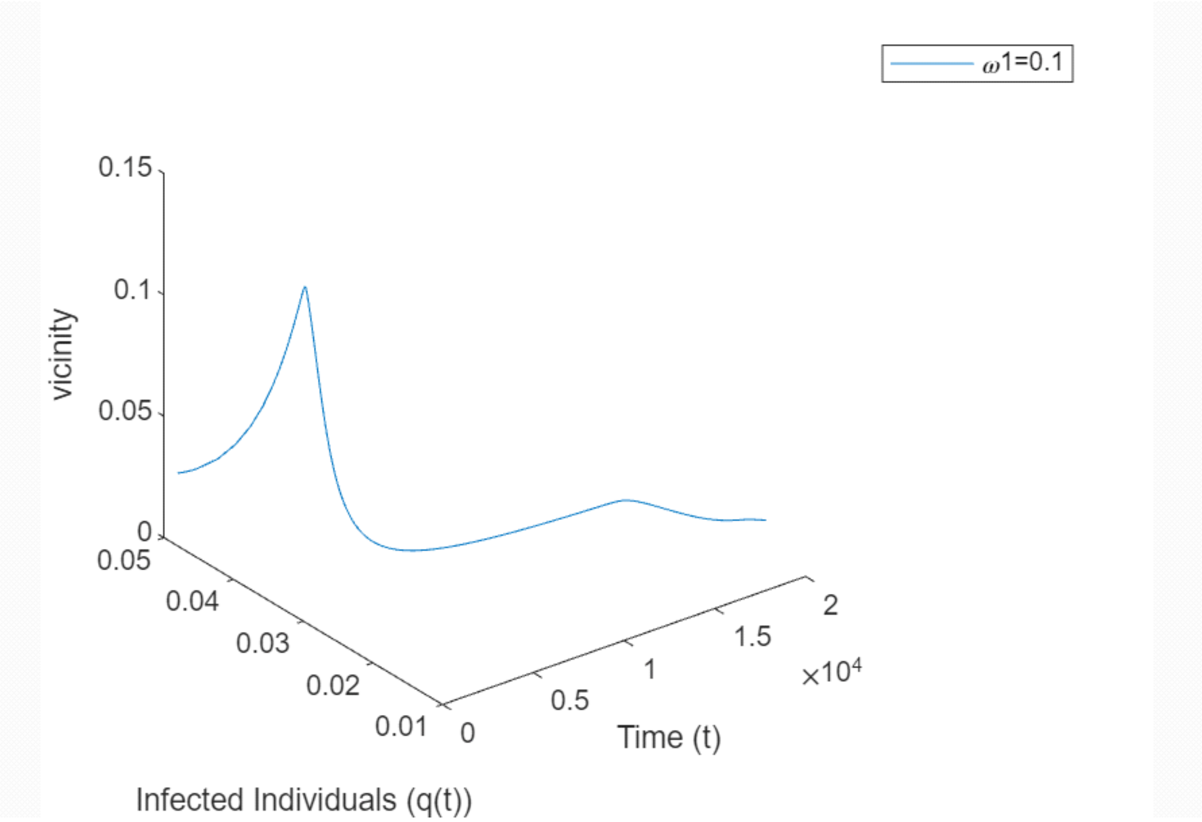

Figure 5

9.3 Non-Vicinity VS Time VS Infected:

CODE:

syms p(t) m(t) l(t) q(t) n(t) T Y

*Eqns=[diff(p(t),t)==-0.1*p(t)*m(t)-0.2*p(t)*l(t);   diff(m(t),t) == 0.1*p(t)*m(t)-0.4*m(t)*q(t); diff(l(t),t) == 0.2*p(t)*l(t)-0.5*l(t)*q(t); diff(q(t),t) == 0.4*m(t)*q(t)+0.5*l(t)*q(t)-(0.1*q(t)/(1+0.2*q(t)))*q(t)*n(t); diff(n(t),t) == (0.1*q(t)/(1+0.2*q(t)))*q(t)*n(t)];*

[DEsys,Subs] = odeToVectorField(Eqns);

```
DEFcn = matlabFunction(DEsys, 'Vars',{T,Y});

tspan = [0,20000];

y0 = [0.08 0.048 0.032 0.03 0.02];

[T,Y] = ode45(DEFcn, tspan, y0);

figure(1)


plot3(T,Y(:,3),Y(:,4));
```

9.4 Output

The above code plots the 3-D graph as:

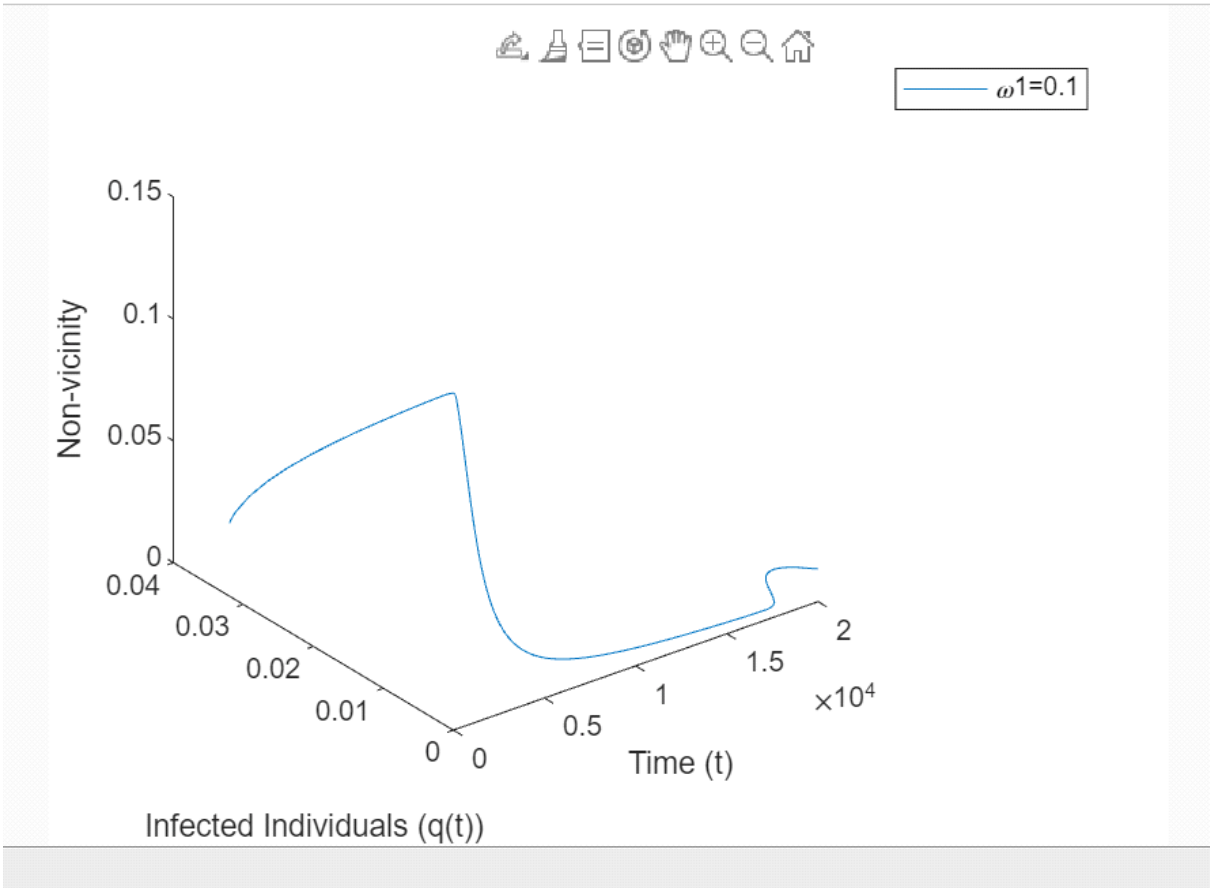

Figure 6

CHAPTER 10

CHANGES IN GRAPH AS PARAMETER CHANGES

10.1 Recovered vs time as alpha changes:

CODE:

```
syms p(t) m(t) l(t) q(t) n(t) T Y
Eqns=[diff(p(t),t)==-0.1*p(t)*m(t)-0.022*p(t)*l(t);
diff(m(t),t) == 0.1*p(t)*m(t)-0.4*m(t)*q(t);
diff(l(t),t) == 0.022*p(t)*l(t)-0.5*l(t)*q(t);
diff(q(t),t) == 0.4*m(t)*q(t)+0.5*l(t)*q(t)-(0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t);
diff(n(t),t) == (0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t)];
[DEsys,Subs] = odeToVectorField(Eqns);
DEFcn = matlabFunction(DEsys, 'Vars',{T,Y});
tspan = [0,20000];
y0 = [0.08 0.048 0.032 0.03 0.02];
[T,Y] = ode45(DEFcn, tspan, y0);
figure(1)
plot(T,Y(:,5));
xlabel('Time (t)')
ylabel('Recovered (m(t))')
legend('\alpha=0.1','\alpha=0.022','\alpha=0.4','\alpha=0.5','\alpha=0.0110')
```

The above code plots graph as:

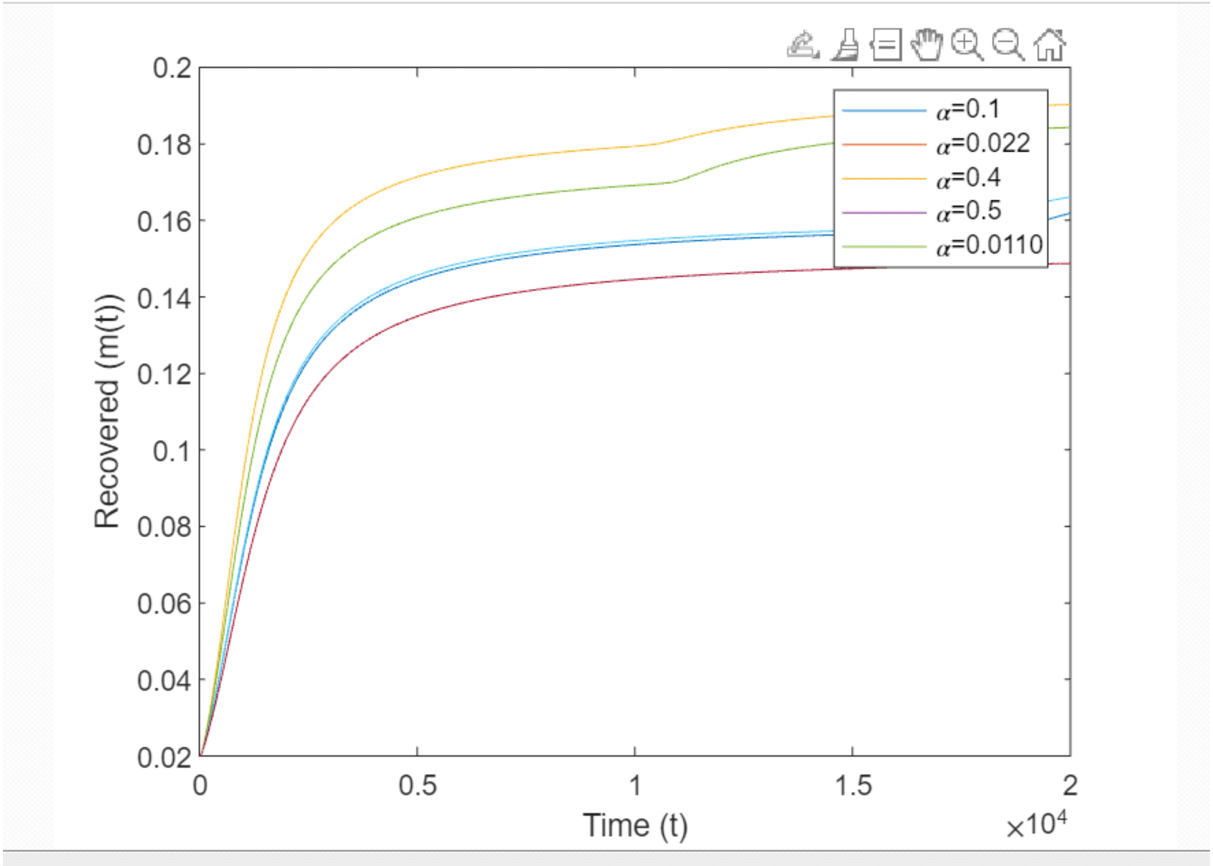

Figure 7

10.2 Non- vicinity vs time as alpha changes:

<u>CODE:</u>

```
syms p(t) m(t) l(t) q(t) n(t) T Y

Eqns=[diff(p(t),t)==-0.1*p(t)*m(t)-0.022*p(t)*l(t);

diff(m(t),t) == 0.1*p(t)*m(t)-0.4*m(t)*q(t);

diff(l(t),t) == 0.022*p(t)*l(t)-0.5*l(t)*q(t);

diff(q(t),t) == 0.4*m(t)*q(t)+0.5*l(t)*q(t)-(0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t);

diff(n(t),t) == (0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t)];
```

```
[DEsys,Subs] = odeToVectorField(Eqns);
DEFcn = matlabFunction(DEsys, 'Vars',{T,Y});
tspan = [0,20000];
y0 = [0.08 0.048 0.032 0.03 0.02];
[T,Y] = ode45(DEFcn, tspan, y0);
figure(1)
plot(T,Y(:,3));
xlabel('Time (t)')
ylabel('Non-Vicinity (m(t))')
legend('\alpha=0.1','\alpha=0.022','\alpha=0.4','\alpha=0.5','\alpha=0.0110')
```

The above code plots the graph as:

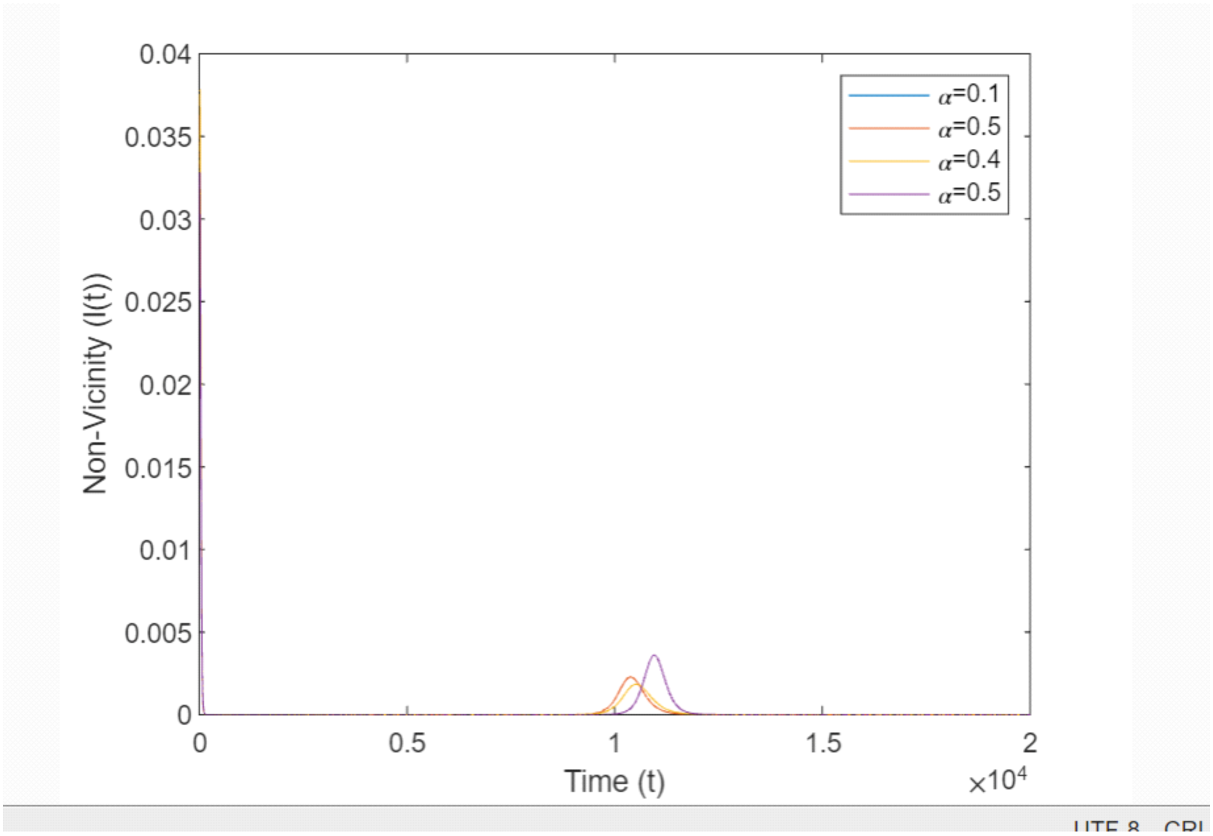

Figure 8

10.3 Vicinity vs time as alpha changes:

CODE:

```
syms p(t) m(t) l(t) q(t) n(t) T Y
Eqns=[diff(p(t),t)==-0.1*p(t)*m(t)-0.022*p(t)*l(t);
diff(m(t),t) == 0.1*p(t)*m(t)-0.4*m(t)*q(t);
diff(l(t),t) == 0.022*p(t)*l(t)-0.5*l(t)*q(t);
diff(q(t),t) == 0.4*m(t)*q(t)+0.5*l(t)*q(t)-(0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t);
diff(n(t),t) == (0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t)];
[DEsys,Subs] = odeToVectorField(Eqns);
DEFcn = matlabFunction(DEsys, 'Vars',{T,Y});
tspan = [0,20000];
y0 = [0.08 0.048 0.032 0.03 0.02];
[T,Y] = ode45(DEFcn, tspan, y0);
figure(1)
plot(T,Y(:,2));
xlabel('Time (t)')
ylabel('Vicinity (m(t))')
legend('\alpha=0.1','\alpha=0.022','\alpha=0.4','\alpha=0.5','\alpha=0.0110')
```

The above code plots the graph as:

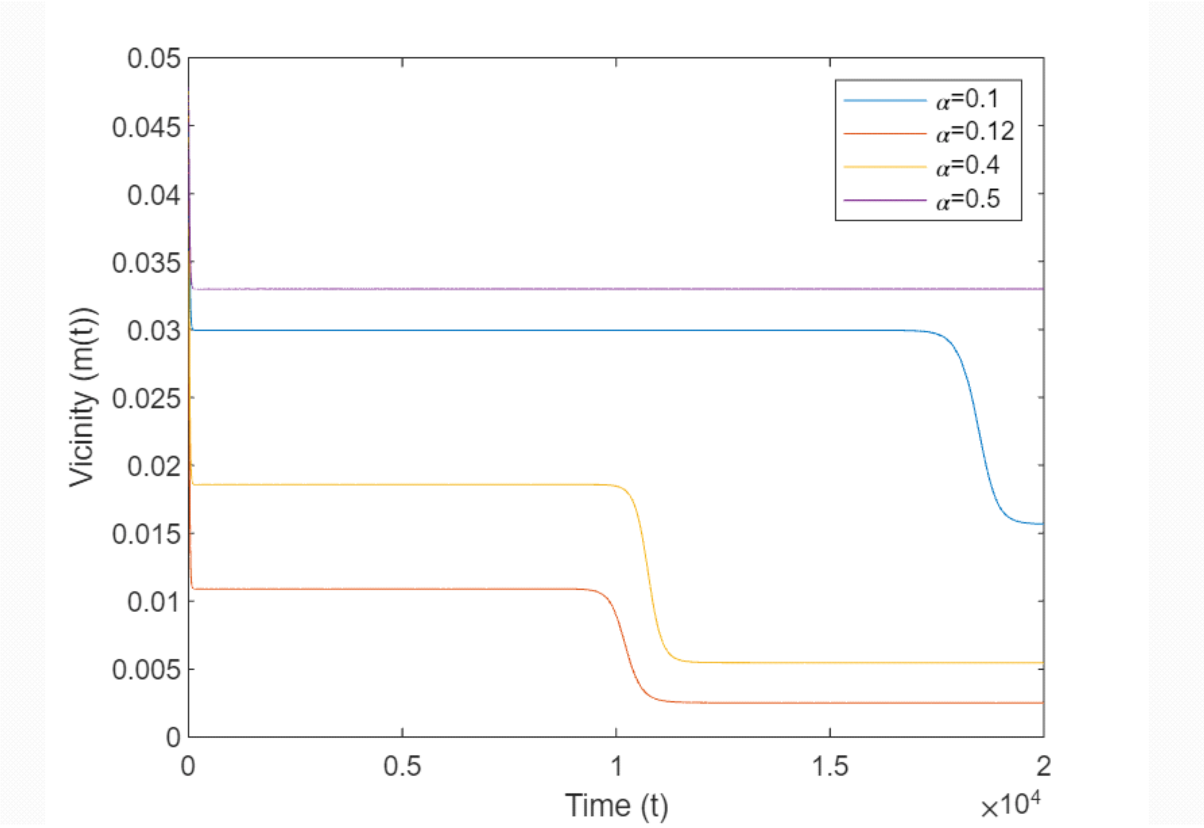

Figure 9

10.4 Infected vs time as delta changes:

CODE:

```
syms p(t) m(t) l(t) q(t) n(t) T Y

Eqns=[diff(p(t),t)==-0.1*p(t)*m(t)-0.022*p(t)*l(t);   diff(m(t),t) == 0.1*p(t)*m(t)-0.4*m(t)*q(t);  diff(l(t),t) == 0.022*p(t)*l(t)-0.5*l(t)*q(t); diff(q(t),t) == 0.4*m(t)*q(t)+0.5*l(t)*q(t)-(0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t);  diff(n(t),t) == (0.1*q(t)/(1+0.022*q(t)))*q(t)*n(t)];

[DEsys,Subs] = odeToVectorField(Eqns);

DEFcn = matlabFunction(DEsys, 'Vars',{T,Y});

tspan = [0,20000];

y0 = [0.08 0.048 0.032 0.03 0.02];

[T,Y] = ode45(DEFcn, tspan, y0);
```

figure(1) plot(T,Y(:,4));

xlabel('Time (t)') ylabel('Infected (m(t))')

legend('\alpha=0.1','\alpha=0.022','\alpha=0.4','\alpha=0.5','\alpha=0.0110')

The above code plots the graph as:

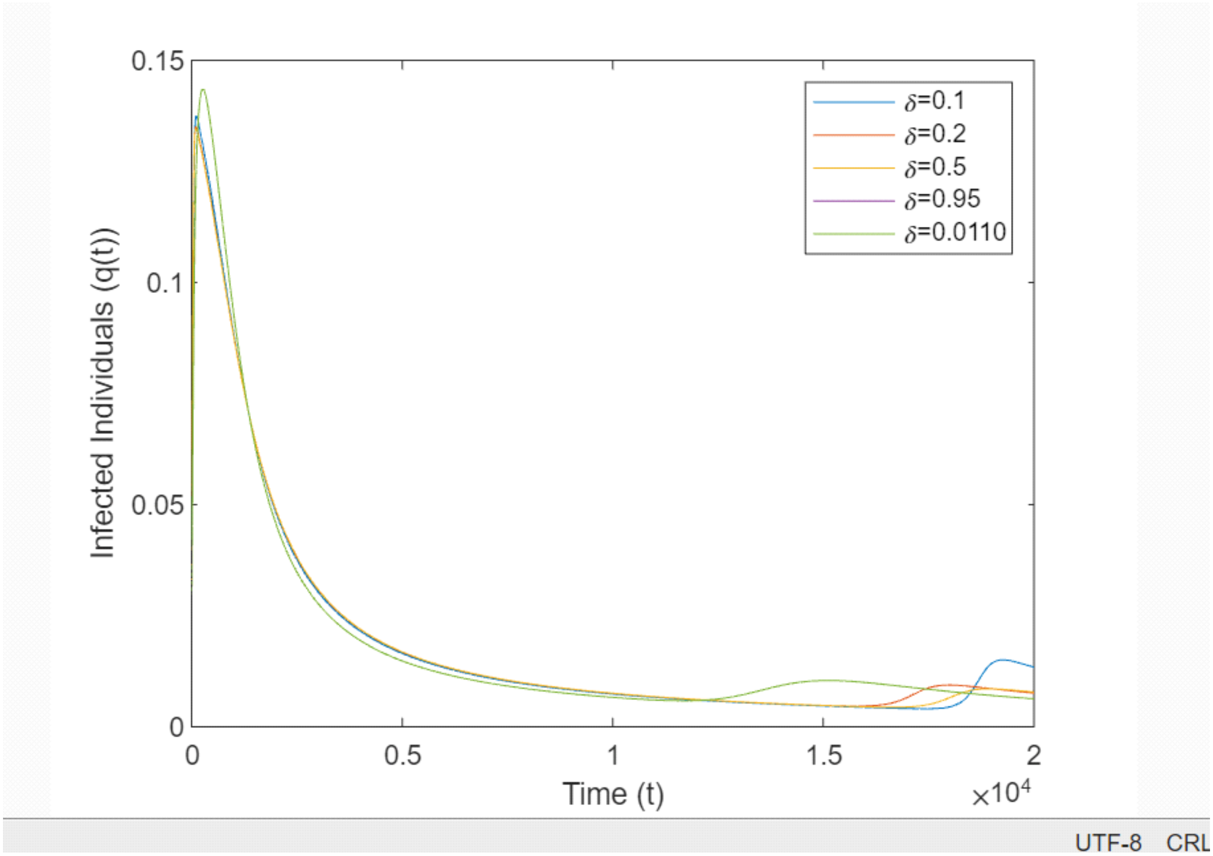

Figure 10

CHAPTER 11

RESULTS

Our analysis shows that rumors can lead to a reduction in student attendance, with the impact being influenced by various factors such as the nature of the rumor, the strength of the student's belief in.

REFERENCES

1. **Figure 1**: https://www.google.com/url?sa=i&url=https%3A%2F%2Fphysics.stackexchange.com%2Fquestions%2F15678%2Fis-mid-water-bouyancy-a-classic-example-of-a-balanced-but-unstable-system&psig=AOvVaw0gGskJ1jshk1fO_yMF1hKw&ust=1684589667676000&source=images&cd=vfe&ved=0CBMQjhxqFwoTCJix59e_gf8CFQAAAAAdAAAAABAJ
2. **Figure 2:** https://www.google.com/url?sa=i&url=https%3A%2F%2Fserc.carleton.edu%2Fintrogeo%2Fmodels%2FEqStBOT.html&psig=AOvVaw0gGskJ1jshk1fO_yMF1hKw&ust=1684589667676000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCNDGp7LAgf8CFQAAAAAdAAAAABAJ
3. **Figure 3**: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.lewuathe.com%2Fcovid-19-dynamics-with-sir-model.html&psig=AOvVaw3ufmimehES1eRc17fhxa_6&ust=1684590175618000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCNjy_snBgf8CFQAAAAAdAAAAABAE
4. file:///C:/Users/wadiy/Downloads/Global_Stability_of_a_Computer_Virus_Propagation_M%20(1).pdf
5. file:///C:/Users/wadiy/Downloads/Dynamics%20of%20a%20glucose%20insulin%20model.pdf
6. http://mdudde.net/pdf/study_material_DDE/M.Sc.MAthematics/DIFFERENTIAL%20EQUATIONS.pdf
7. https://web.tuat.ac.jp/~gvlab/ronbun/ReadingGroupControl/mls-lyap.pdf
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