Practical No.-4

Question 4:

1. Design and Develop a System Dynamic Model
   i. Create a Stock flow diagram.
   ii. Adding a plot to Visualize Dynamics.
   iii. Parameter Variation
   iv. Calibration

SEIR Model: Susceptible Exposed Infectious Recovered

Aim:

To develop a System Dynamics model using AnyLogic to simulate the spread of a contagious disease based on the SEIR (Susceptible Exposed Infectious Recovered) model.

Theory:

System Dynamics is a methodology for understanding the dynamic behaviour of complex systems over time. It involves creating stock-flow diagrams to represent the system's structure and behaviour, along with equations to describe the flow of entities between stocks. In the context of disease spread, the SEIR model divides the population into four compartments: Susceptible (S), Exposed (E), Infectious (I), and Recovered (R). The model tracks the flow of individuals between these compartments over time.

Procedure:

Step 1: Create a Stock Flow Diagram

- Identify the key components of the SEIR model: Susceptible, Exposed, Infectious, and Recovered.
- Use AnyLogic's graphical interface to create stocks representing each compartment.
- Define flows between the compartments to represent the dynamics of disease transmission and recovery.

Step 2: Adding a Plot to Visualize Dynamics

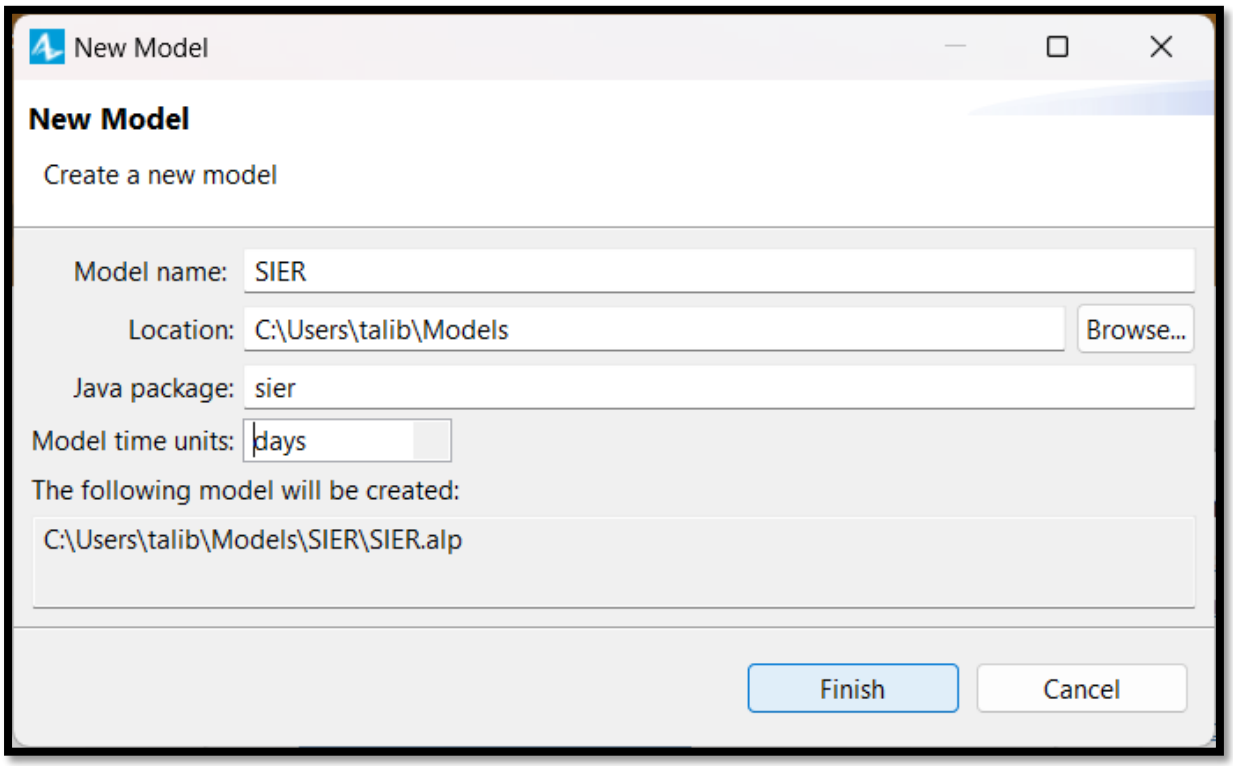
- Add a plot to the model to visualize the changes in the population of each compartment over time.
- Configure the plot to display the population of Susceptible, Exposed, Infectious, and Recovered individuals.

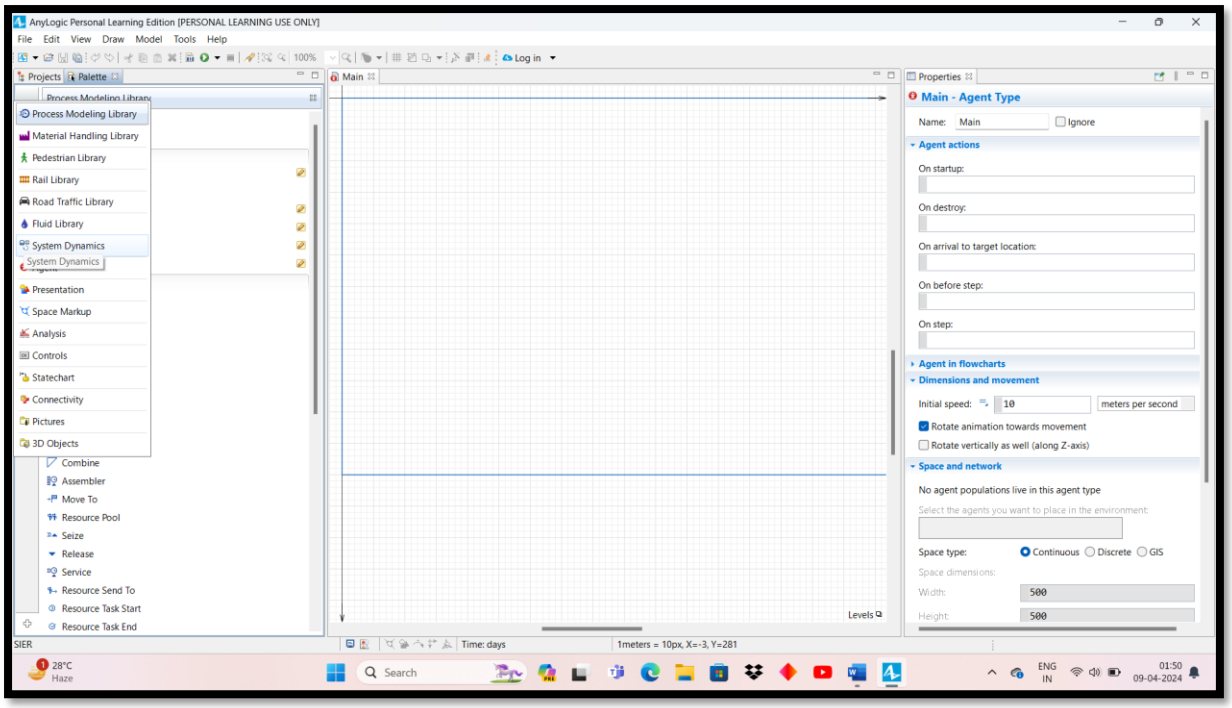
Step 3: Parameter Variation

- Define parameters such as transmission rate, incubation period, and recovery rate.
- Implement parameter variation to observe the effects of different parameter values on the dynamics of disease spread.
- Use sliders or input fields in the model interface to allow users to adjust parameter values interactively.

Step 4: Calibration

- Calibrate the model using real-world data or estimates for parameters such as transmission rate and recovery rate.
- Adjust the model's parameters to match the observed patterns of disease spread in the calibration data.
- Validate the calibrated model by comparing its predictions to historical data or independent sources.




AnyLogic Personal Learning Edition [PERSONAL LEARNING USE ONLY]
File Edit View Draw Model Tools Help
Projects Palette
Process Modeling Library
Material Handling Library
Pedestrian Library
Rail Library
Road Traffic Library
Fluid Library
System Dynamics
Presentation
Space Markup
Analysis
Controls
Statechart
Connectivity
Pictures
3D Objects
Combine
Assembler
Move To
Resource Pool
Seize
Release
Service
Resource Send To
Resource Task Start
Resource Task End
Main
Properties
Main - Agent Type
Name: Main
Ignore
Agent actions
On startup:
On destroy:
On arrival to target location:
On before step:
On step:
Agent in flowcharts
Dimensions and movement
Initial speed: 10 meters per second
Rotate animation towards movement
Rotate vertically as well (along Z-axis)
Space and network
No agent populations live in this agent type
Select the agents you want to place in the environment:
Space type: Continuous Discrete GIS
Space dimensions:
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Height: 500
Levels
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28°C Haze
Search
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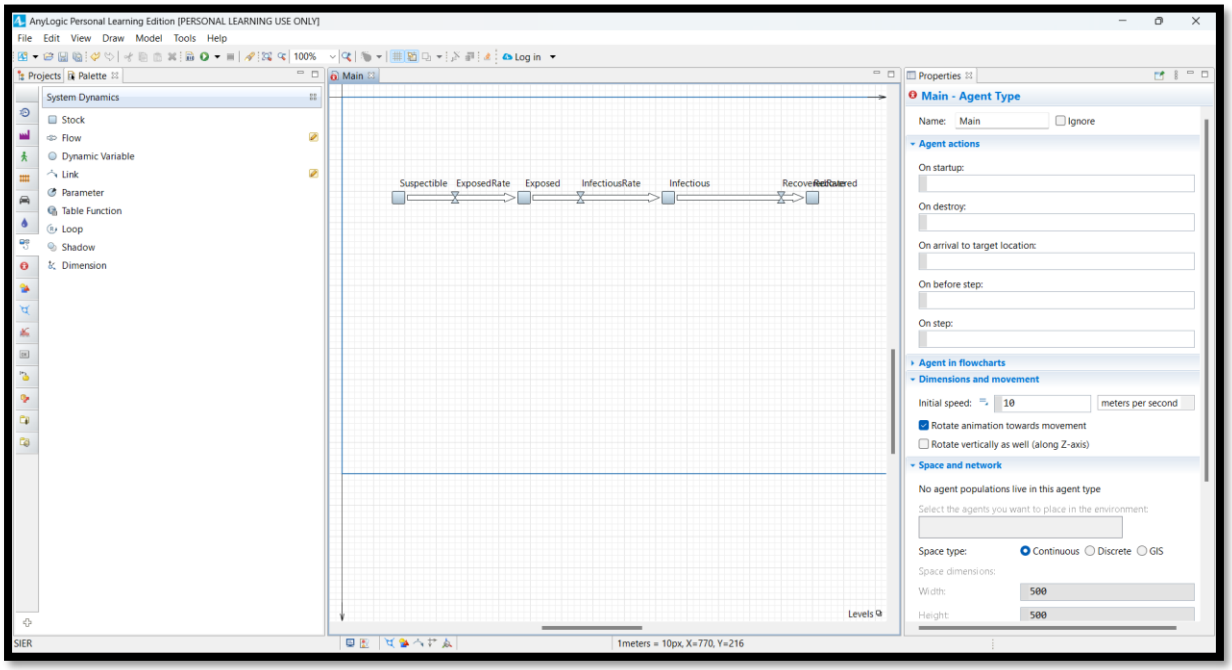
AnyLogic Personal Learning Edition [PERSONAL LEARNING USE ONLY]
File Edit View Draw Model Tools Help
Projects Palette
System Dynamics
Stock
Flow
Dynamic Variable
Link
Parameter
Table Function
Loop
Shadow
Dimension
Main
Suspectible
ExposedRate
Exposed
InfectiousRate
Infectious
Properties
Main - Agent Type
Name: Main
Ignore
Agent actions
On startup:
On destroy:
On arrival to target location:
On before step:
On step:
Agent in flowcharts
Dimensions and movement
Initial speed: 10 meters per second
Rotate animation towards movement
Rotate vertically as well (along Z-axis)
Space and network
No agent populations live in this agent type
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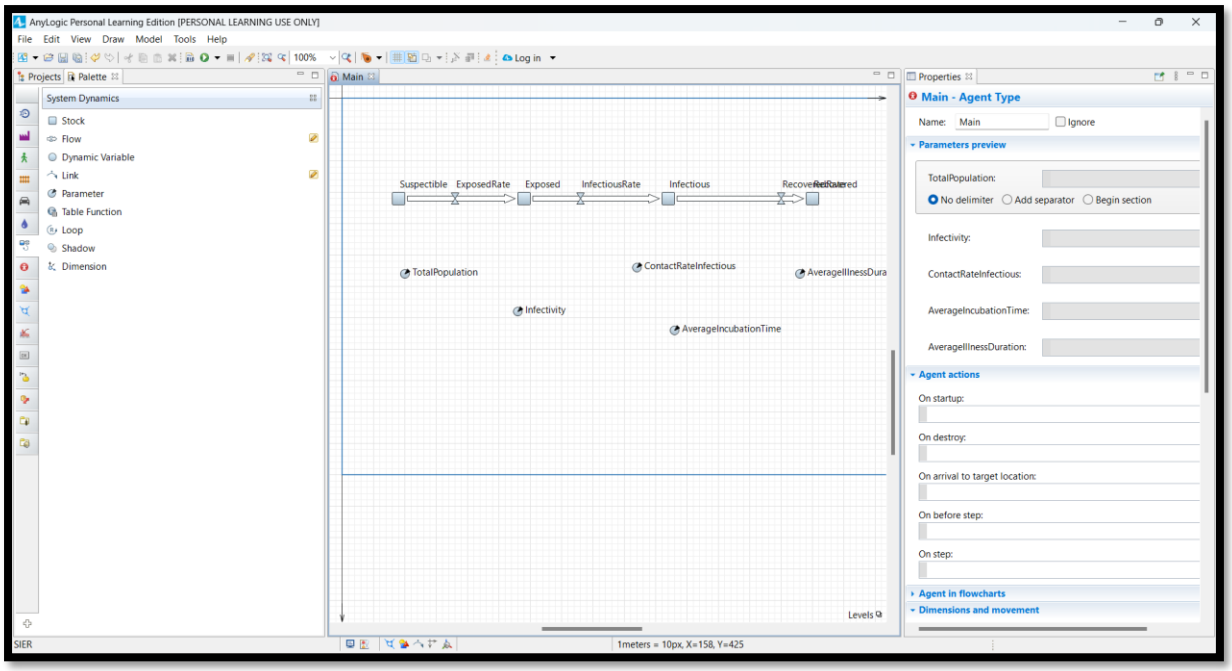
AnyLogic Personal Learning Edition [PERSONAL LEARNING USE ONLY]
File Edit View Draw Model Tools Help
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System Dynamics
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Table Function
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Dimension
Main
Suspectible ExposedRate Exposed InfectiousRate Infectious
TotalPopulation
ContactRateInfectious
Infectivity
AverageIncubationTime
Levels
Properties
Main - Agent Type
Name: Main
Ignore
Parameters preview
TotalPopulation:
No delimiter Add separator Begin section
Infectivity:
ContactRateInfectious:
AverageIncubationTime:
AverageIllnessDuration:
Agent actions
On startup:
On destroy:
On arrival to target location:
On before step:
On step:
Agent in flowcharts
Dimensions and movement
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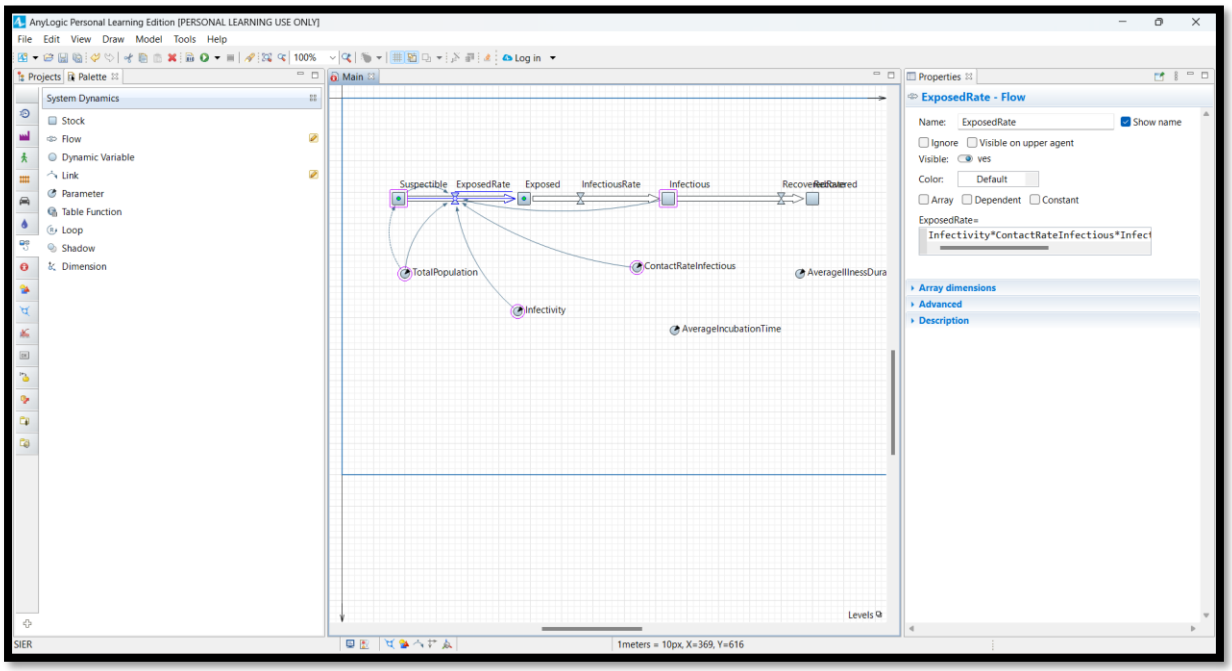
AnyLogic Personal Learning Edition [PERSONAL LEARNING USE ONLY]
File Edit View Draw Model Tools Help
Projects Palette
System Dynamics
Stock
Flow
Dynamic Variable
Link
Parameter
Table Function
Loop
Shadow
Dimension
Main
Suspectible ExposedRate Exposed InfectiousRate Infectious
TotalPopulation
ContactRateInfectious
Infectivity
AverageIncubationTime
Levels
Properties
ExposedRate - Flow
Name: ExposedRate
Show name
Ignore Visible on upper agent
Visible: yes
Color: Default
Array Dependent Constant
ExposedRate=
Infectivity*ContactRateInfectious*Infect
Array dimensions
Advanced
Description
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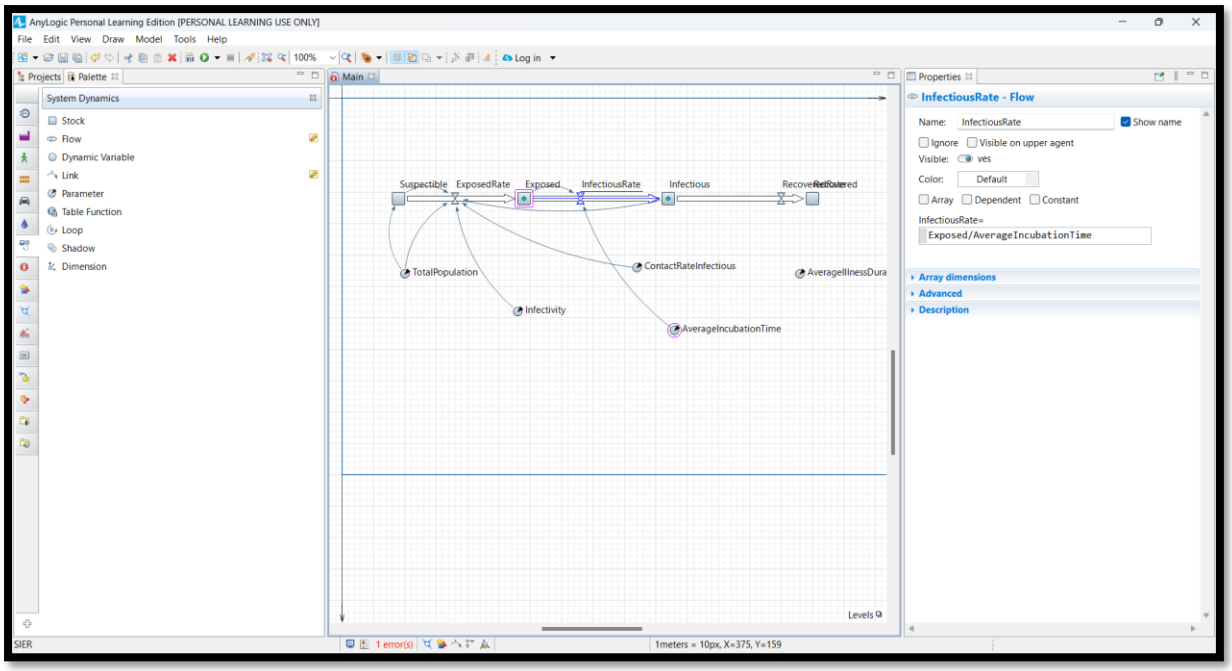
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File Edit View Draw Model Tools Help
Projects Palette
System Dynamics
Stock
Flow
Dynamic Variable
Link
Parameter
Table Function
Loop
Shadow
Dimension
Main
Suspectible
ExposedRate
Exposed
InfectiousRate
Infectious
TotalPopulation
ContactRateInfectious
Infectivity
AverageIncubationTime
Properties
InfectiousRate - Flow
Name: InfectiousRate
Show name
Ignore
Visible on upper agent
Visible: yes
Color: Default
Array
Dependent
Constant
InfectiousRate=
Exposed/AverageIncubationTime
Array dimensions
Advanced
Description
Levels
SIER
1 error(s)
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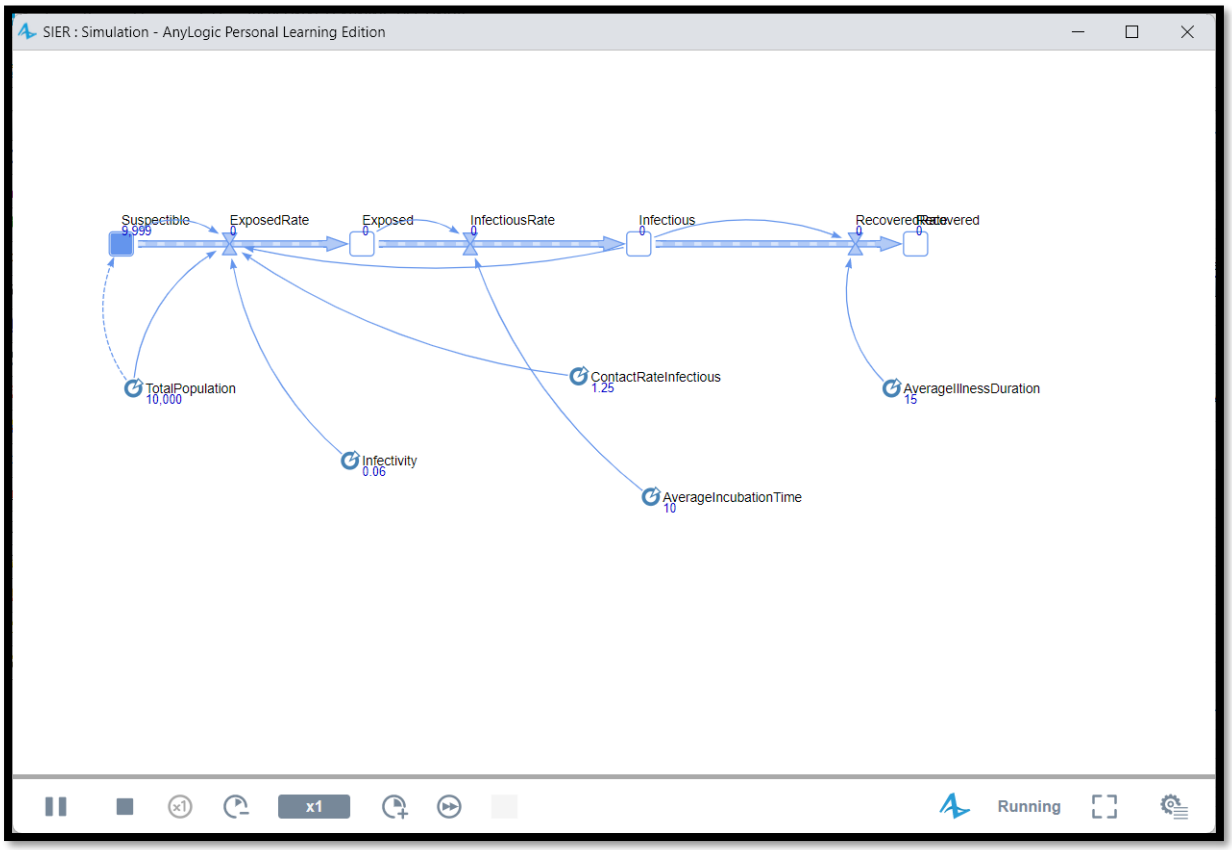
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ExposedRate
0
Exposed
0
InfectiousRate
0
Infectious
0
0
0
TotalPopulation
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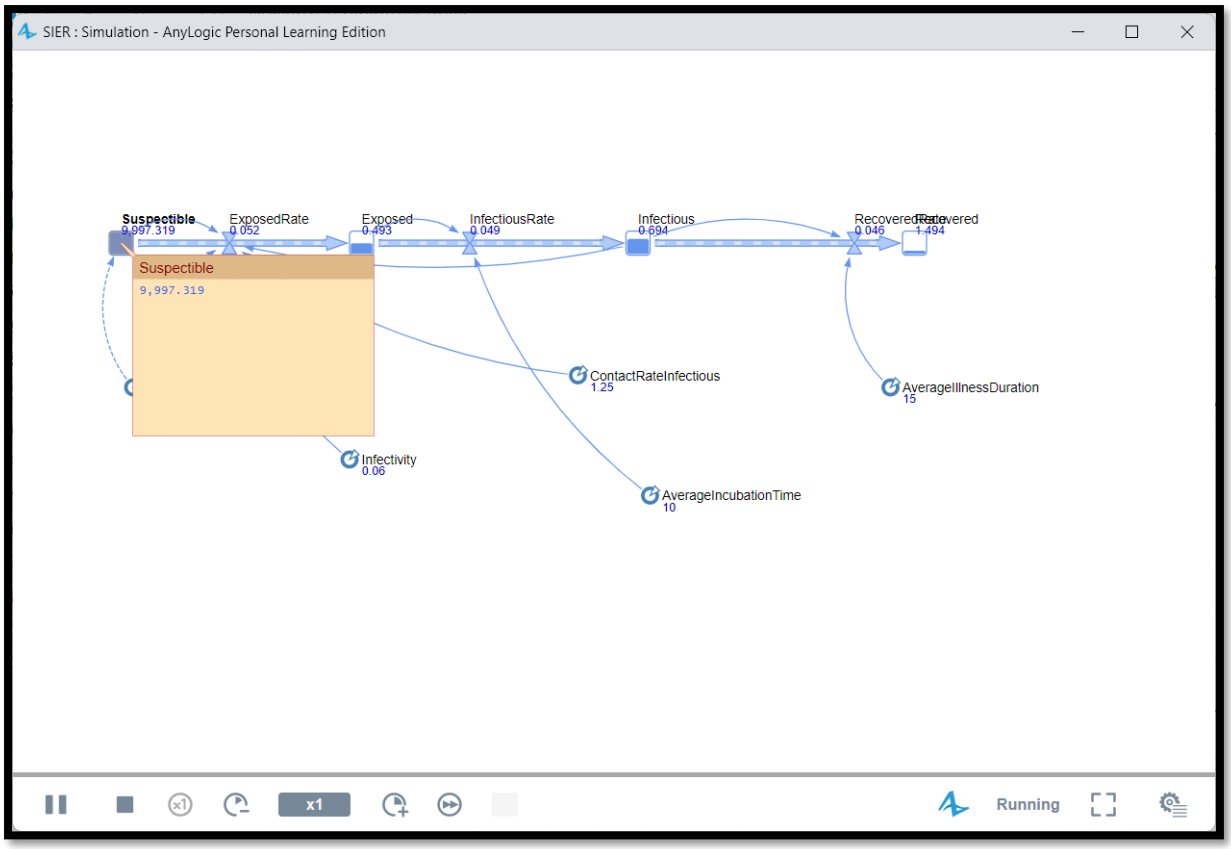
AverageIllnessDuration
15
Infectivity
0.06
AverageIncubationTime
10
x1
Running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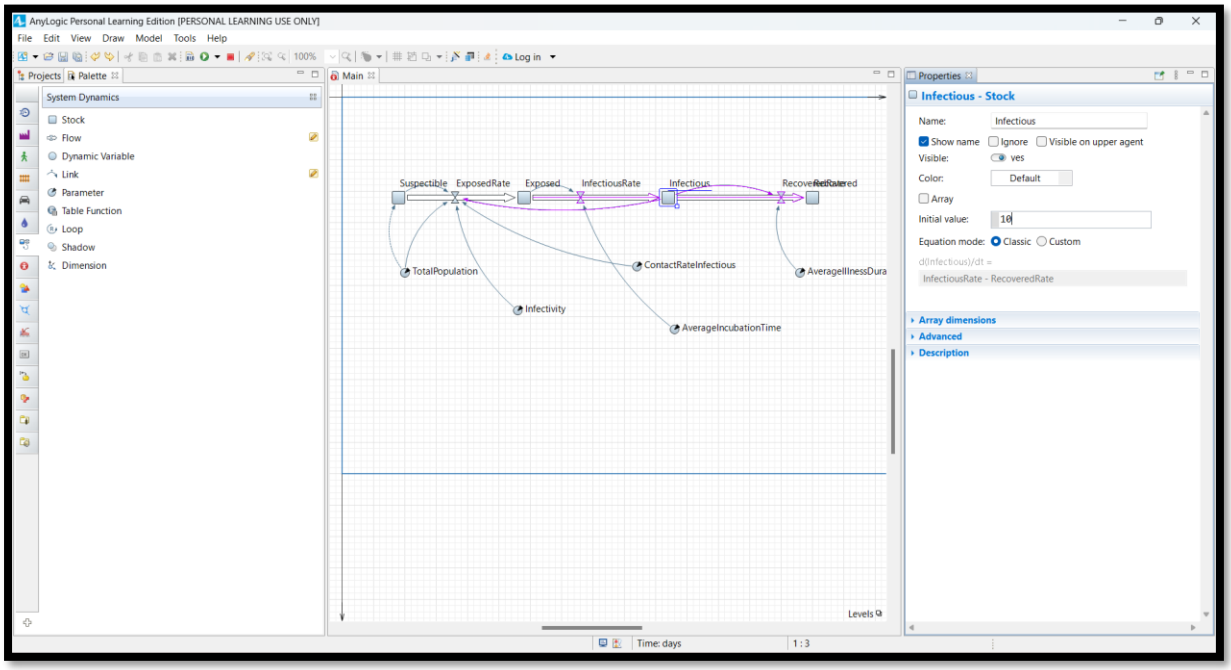
Exposed
0.493
InfectiousRate
0.049
Infectious
0.694
RecoveredRate
0.046
Recovered
1.494
Suspectible
9,997.319
ContactRateInfectious
1.25
AverageIllnessDuration
15
Infectivity
0.06
AverageIncubationTime
10
x1
Running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File Edit View Draw Model Tools Help
Projects
Palette
System Dynamics
Stock
Flow
Dynamic Variable
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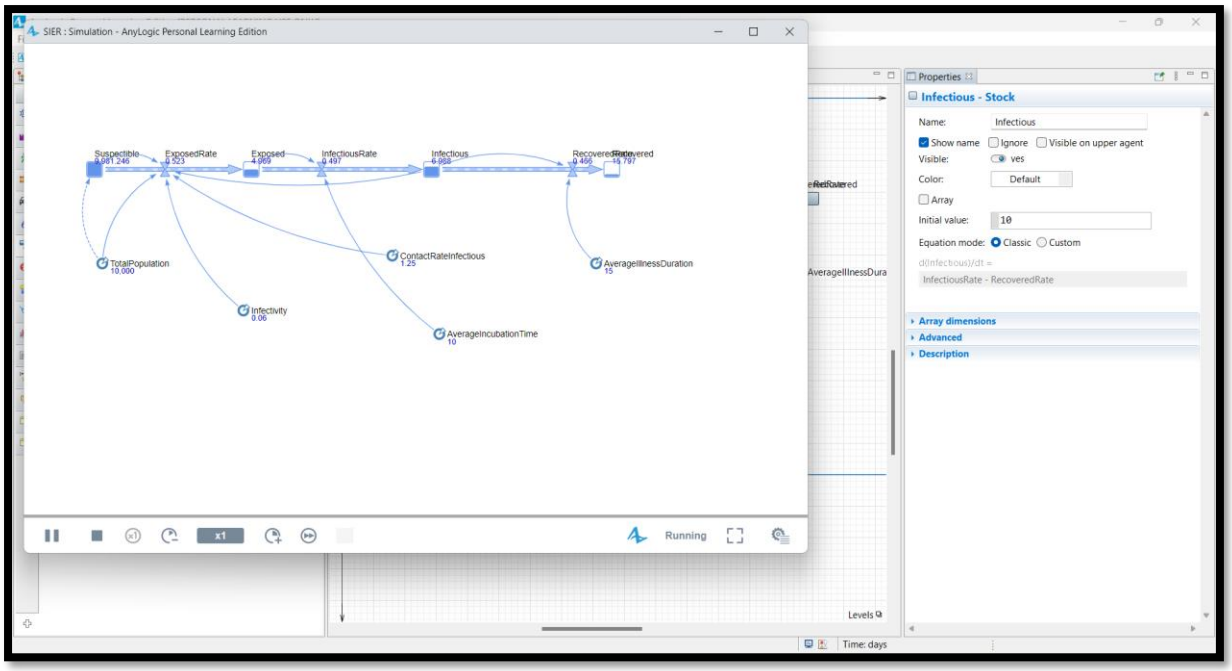
Table Function
Loop
Shadow
Dimension
Main
Suspectible
ExposedRate
Exposed
InfectiousRate
Infectious
TotalPopulation
ContactRateInfectious
Infectivity
AverageIncubationTime
Levels
Properties
Infectious - Stock
Name: Infectious
Show name
Ignore
Visible on upper agent
Visible:
Color:
Default
Array
Initial value:
10
Equation mode:
Classic
Custom
Array dimensions
Advanced
Description
Time: days
1 : 3


SIER : Simulation - AnyLogic Personal Learning Edition
Suspectible
ExposedRate
Exposed
InfectiousRate
Infectious
RecoveredRate
Recovered
TotalPopulation
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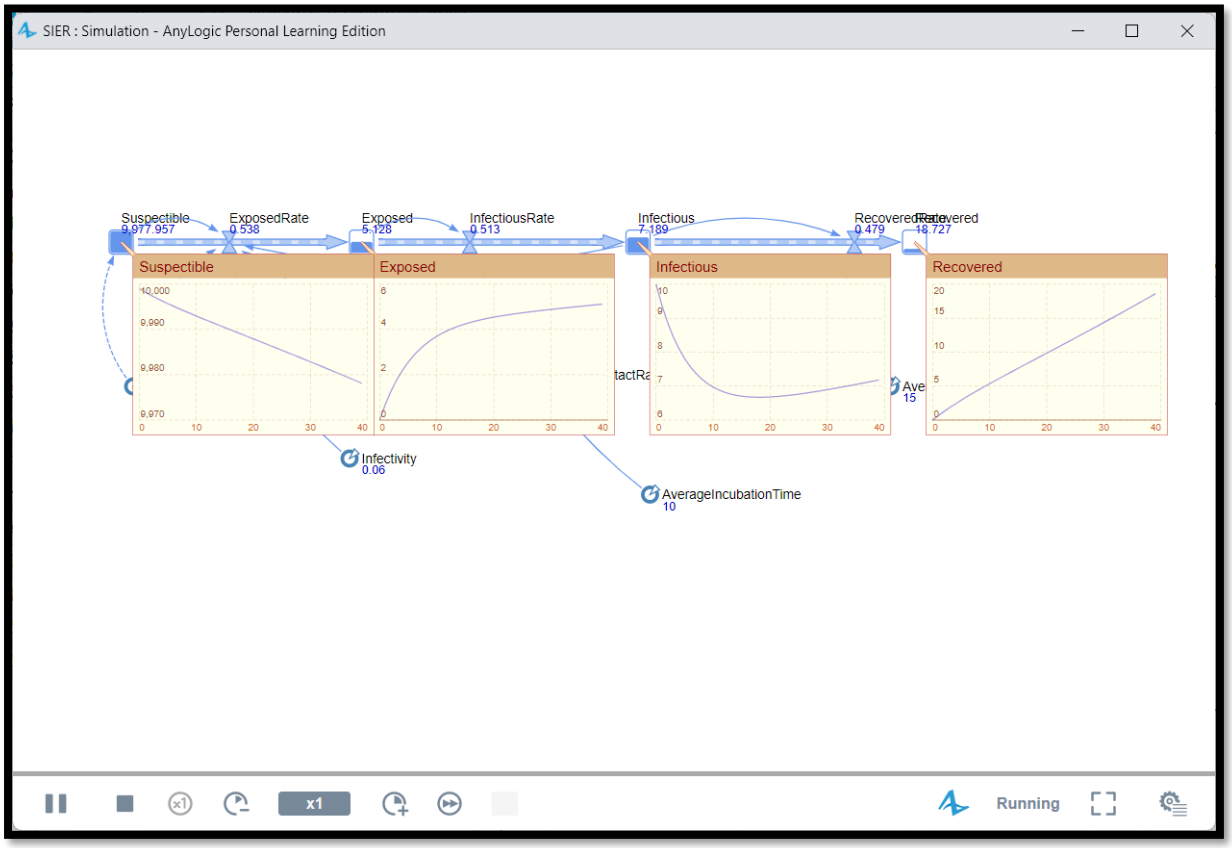
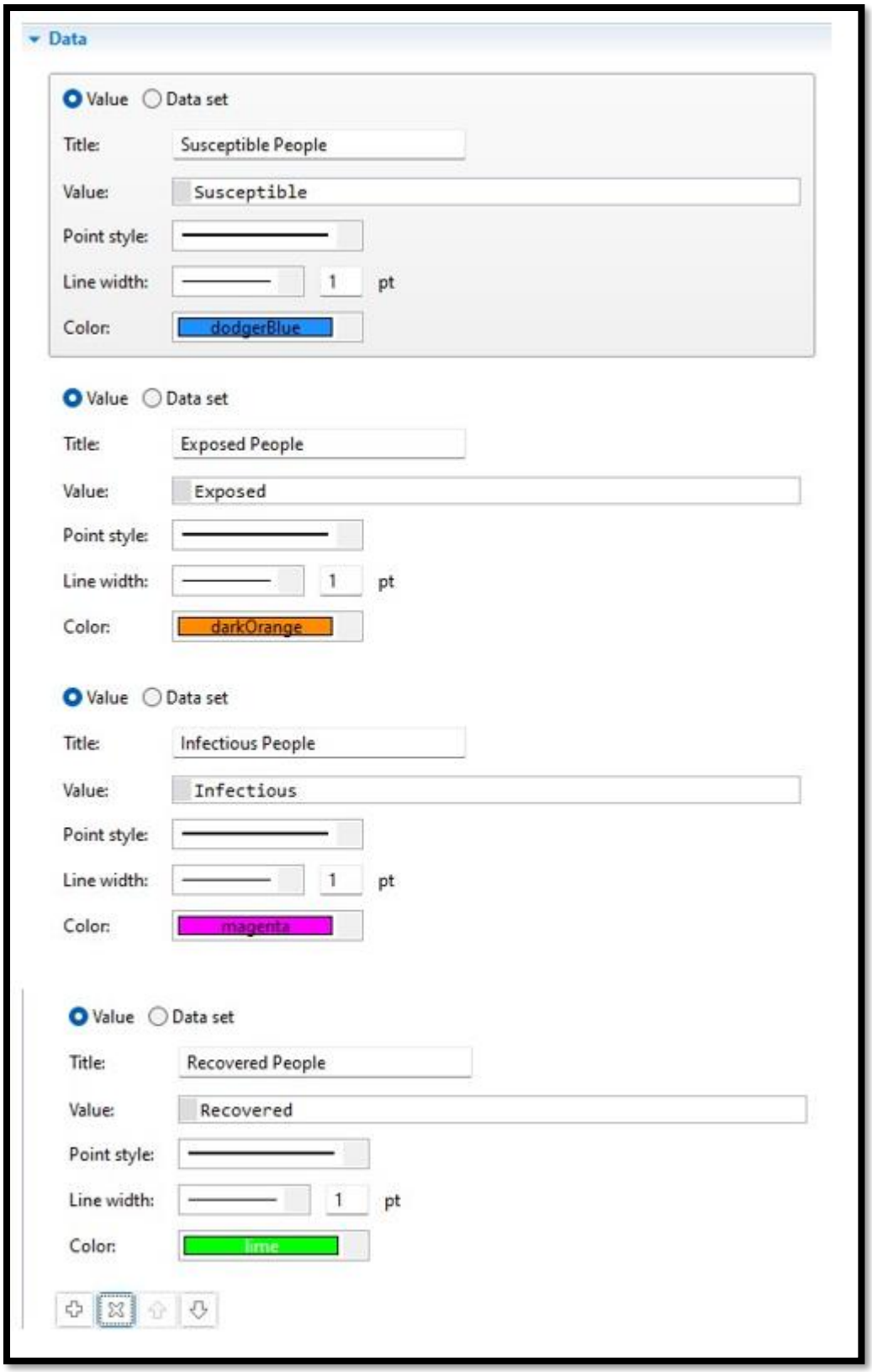
ContactRateInfectious
1.25
AverageIllnessDuration
15
Infectivity
0.06
AverageIncubationTime
10
x1
Running
Properties
Infectious - Stock
Name:
Infectious
Show name
Ignore
Visible on upper agent
Visible:
yes
Color:
Default
Array
Initial value:
10
Equation mode:
Classic
Custom
dI(Infectious)/dt =
InfectiousRate - RecoveredRate
Array dimensions
Advanced
Description
Levels
Time: days


SIER : Simulation - AnyLogic Personal Learning Edition
Suspectible
9,977.957
ExposedRate
0.538
Exposed
5.128
InfectiousRate
0.513
Infectious
7.189
RecoveredRate
0.479
Recovered
18.727
Suspectible
Exposed
Infectious
Recovered
Infectivity
0.06
AverageIncubationTime
10
x1
Running


Data
Value
Data set
Title:
Susceptible People
Value:
Susceptible
Point style:
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Color:
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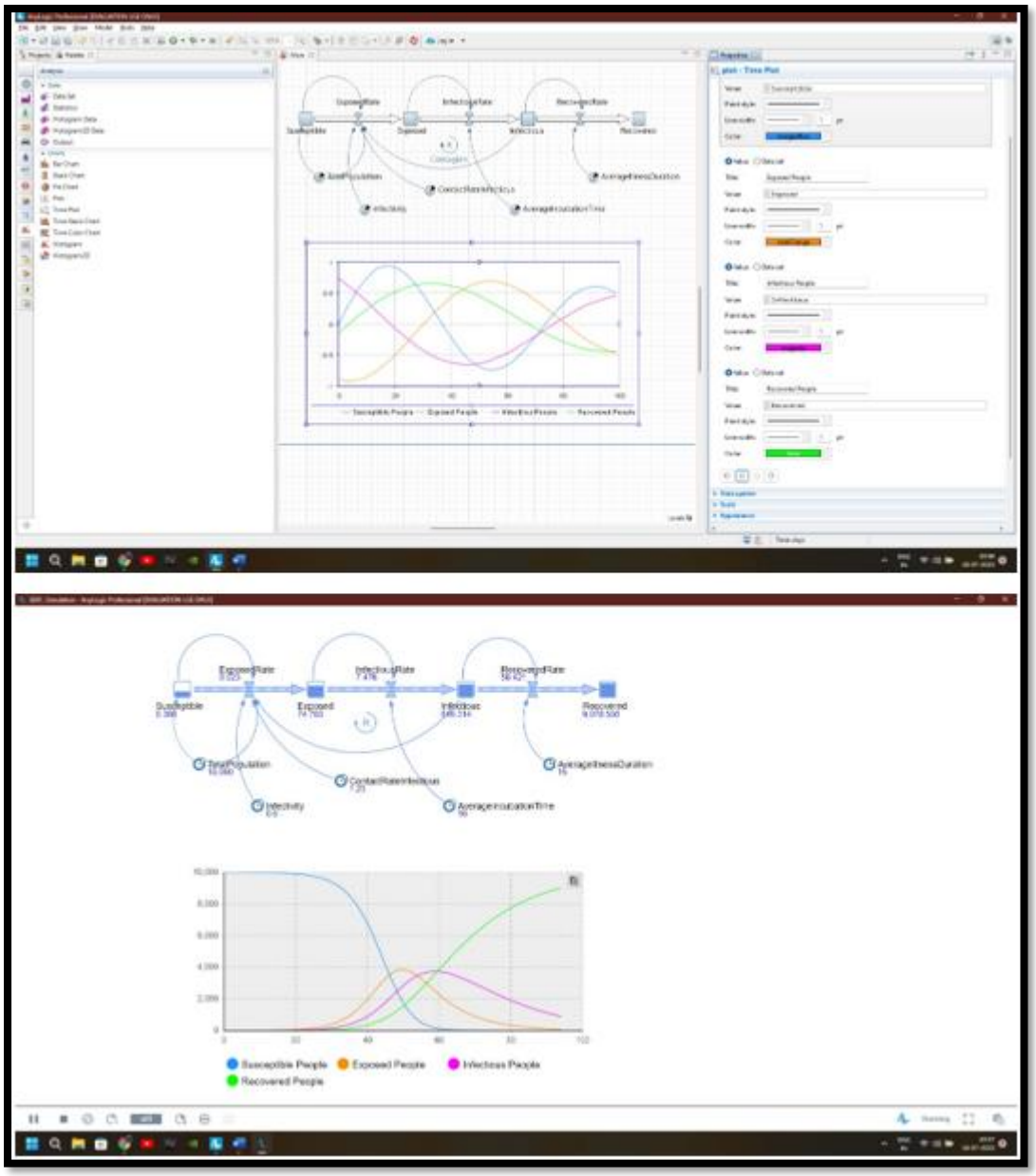
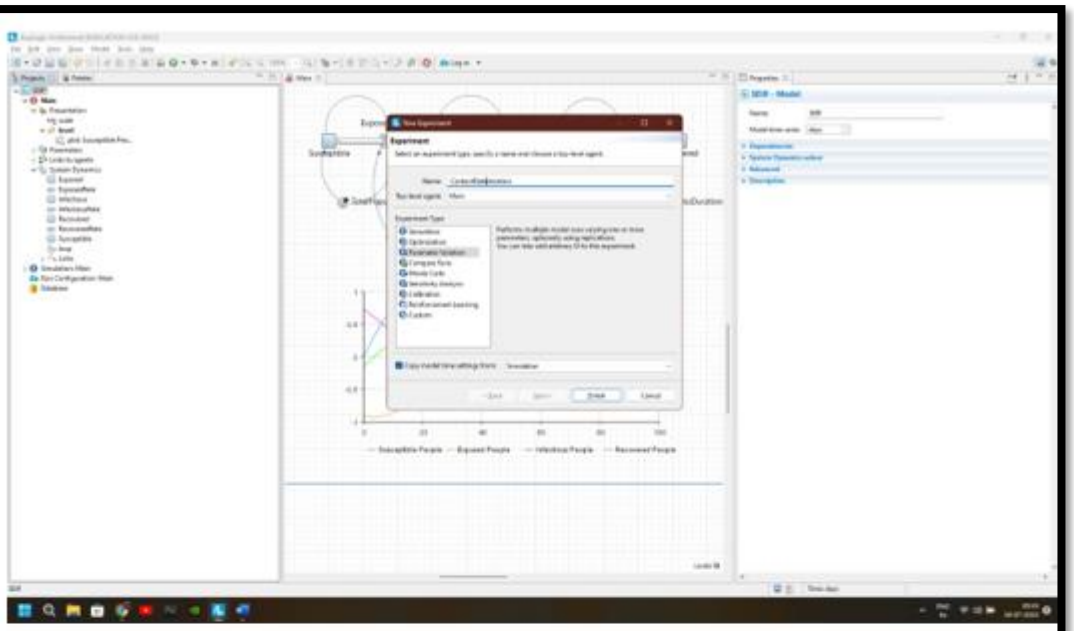
Value
Data set
Title:
Exposed People
Value:
Exposed
Point style:
Line width:
1
pt
Color:
darkOrange
Value
Data set
Title:
Infectious People
Value:
Infectious
Point style:
Line width:
1
pt
Color:
magenta
Value
Data set
Title:
Recovered People
Value:
Recovered
Point style:
Line width:
1
pt
Color:
lime


ExposedRate
InfectiousRate
RecoveredRate
Susceptible
Exposed
Infectious
Recovered
TotalPopulation
ContactRateInfectious
Infectivity
AverageIncubationTime
AverageIllnessDuration
Susceptible People
Exposed People
Infectious People
Recovered People



Parameters

Parameters: (•) Varied in range ( ) Freeform

Number of runs: 10

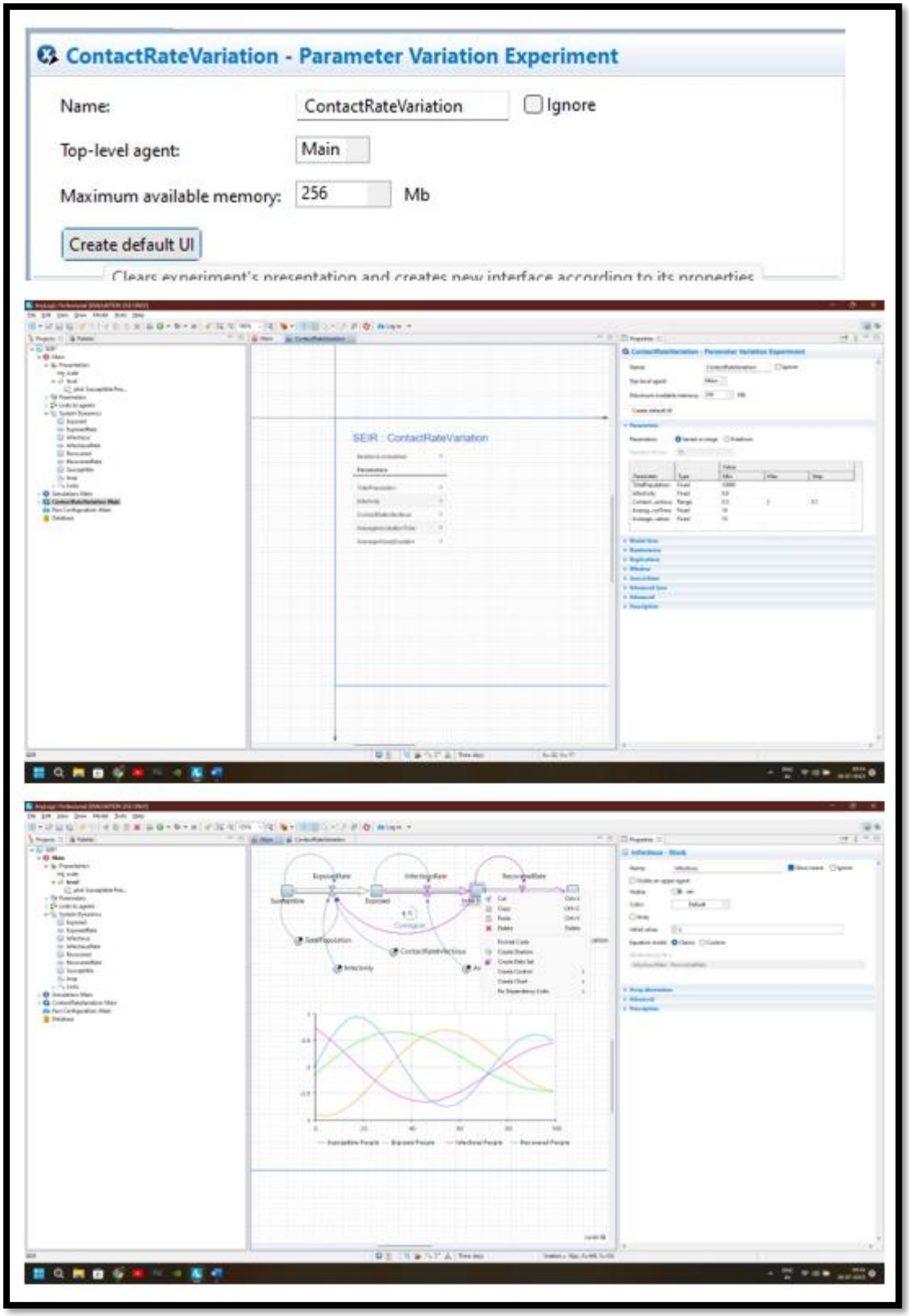
Parameter	Type	Value		
		Min	Max	Step
TotalPopulation	Fixed	10000		
Infectivity	Fixed	0.6		
Contact...ectious	Fixed	1.25		
Averag...onTime	Fixed	10		
Average...ration	Fixed	15		

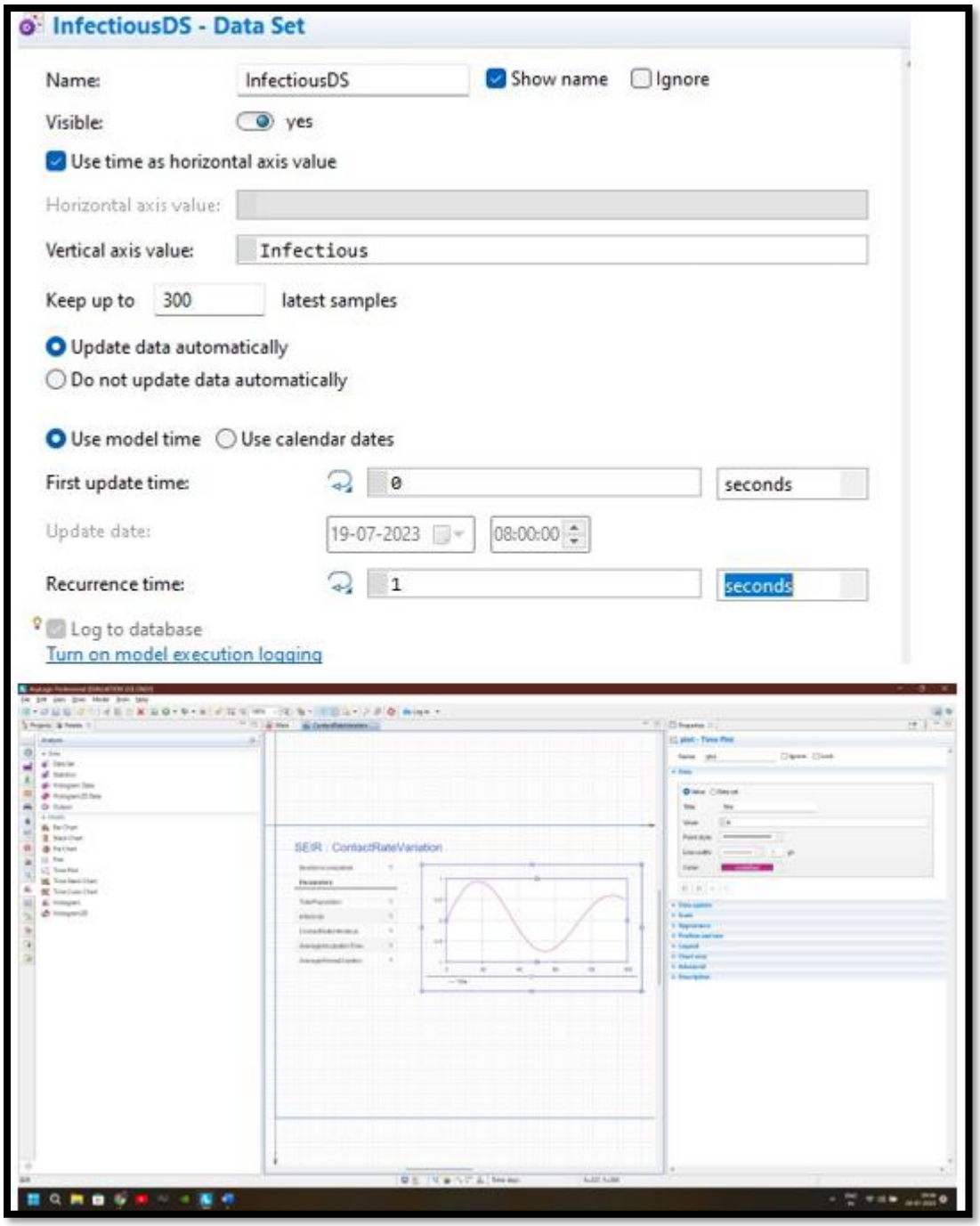
Parameters

Parameters: (•) Varied in range ( ) Freeform

Number of runs: 10

Parameter	Type	Value		
		Min	Max	Step
TotalPopulation	Fixed	10000		
Infectivity	Fixed	0.6		
Contact...ectious	Range	0.3	2	0.1
Averag...onTime	Fixed	10		
Average...ration	Fixed	15		


ContactRateVariation - Parameter Variation Experiment
Name:
ContactRateVariation
Ignore
Top-level agent:
Main
Maximum available memory:
256
Mb
Create default UI
Clears experiment's presentation and creates new interface according to its properties
SEIR : ContactRateVariation


InfectiousDS - Data Set
Name:
InfectiousDS
Show name
Ignore
Visible:
yes
Use time as horizontal axis value
Horizontal axis value:
Vertical axis value:
Infectious
Keep up to
300
latest samples
Update data automatically
Do not update data automatically
Use model time
Use calendar dates
First update time:
0
seconds
Update date:
19-07-2023
08:00:00
Recurrence time:
1
seconds
Log to database
Turn on model execution logging
SEIR : ContactRateVariation

Conclusion:

In this practical, we successfully designed and developed a System Dynamics model using AnyLogic to simulate the spread of a contagious disease based on the SEIR model. By creating a stock-flow diagram, adding plots to visualize dynamics, implementing parameter variation, and calibrating the model, we gained insights into the dynamics of disease spread and explored the effects of different parameters on the epidemic trajectory. This model can be further refined and used to inform public health decision-making and interventions aimed at controlling infectious diseases.